Connecting via Winsock to STN

Welcome to STN International! Enter x:X

LOGINID:ssptamls1742

PASSWORD:
TERMINAL (ENTER 1, 2, 3, OR ?):2

* * * * * * * * *   Welcome to STN International   * * * * * * * * * *

 NEWS 1   Web Page for STN Seminar Schedule - N. America
 NEWS 2 NOV 21 CAS patent coverage to include exemplified prophetic
                  substances identified in English-, French-, German-,
                  and Japanese-language basic patents from 2004-present
 NEWS 3 NOV 26 MARPAT enhanced with FSORT command
 NEWS 4 NOV 26 CHEMSAFE now available on STN Easy
 NEWS 5 NOV 26 Two new SET commands increase convenience of STN
                  searching
 NEWS 6 DEC 01 ChemPort single article sales feature unavailable
 NEWS 7 DEC 12 GBFULL now offers single source for full-text
                  coverage of complete UK patent families
 NEWS 8 DEC 17 Fifty-one pharmaceutical ingredients added to PS
 NEWS 9 JAN 06 The retention policy for unread STNmail messages
                  will change in 2009 for STN-Columbus and STN-Tokyo
 NEWS 10 JAN 07 WPIDS, WPINDEX, and WPIX enhanced Japanese Patent
                  Classification Data

 NEWS EXPRESS JUNE 27 08 CURRENT WINDOWS VERSION IS V8.3,
              AND CURRENT DISCOVER FILE IS DATED 23 JUNE 2008.

 NEWS HOURS   STN Operating Hours Plus Help Desk Availability
 NEWS LOGIN   Welcome Banner and News Items
 NEWS IPC8   For general information regarding STN implementation of IPC 8

Enter NEWS followed by the item number or name to see news on that
specific topic.

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  research. Use for software development or design or implementation
  of commercial gateways or other similar uses is prohibited and may
  result in loss of user privileges and other penalties.

* * * * * * * * * * * * * STN Columbus * * * * * * * * * * * * * * *

FILE 'HOME' ENTERED AT 19:41:09 ON 31 JAN 2009

=> file registry
COST IN U.S. DOLLARS   SINCE FILE   TOTAL
                                                       ENTRY   SESSION
FULL ESTIMATED COST   0.22   0.22

FILE 'REGISTRY' ENTERED AT 19:41:54 ON 31 JAN 2009
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DICTIONARY FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3

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predicted properties as well as tags indicating availability of
experimental property data in the original document. For information
on property searching in REGISTRY, refer to:

http://www.cas.org/support/stngen/stndoc/properties.html

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
               (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
               (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
               (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
               (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
               (0.1-0.3/MAC (P) MO/MAC)
L1   1415 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
               CR/MAC AND 0.1-0.3 MO/MAC

=> l1 and 0-0.30 Cu/mac
L1 IS NOT A RECOGNIZED COMMAND
The previous command name entered was not recognized by the system.
For a list of commands available to you in the current file, enter
"HELP COMMANDS" at an arrow prompt (=>).

=> s l1 and 0-0.30 Cu/mac
        475715 0-0.30/MAC
        245265 CU/MAC
         60826 0-0.30 CU/MAC
               (0-0.30/MAC (P) CU/MAC)
L2   692 L1 AND 0-0.30 CU/MAC

=> file caplus, uspatfull, scisearch
COST IN U.S. DOLLARS   SINCE FILE   TOTAL
                                                   ENTRY   SESSION

=> s l1 and steel
'MAC' IS NOT A VALID FIELD CODE
L3   1668 L1 AND STEEL

=> s l2 and steel
'MAC' IS NOT A VALID FIELD CODE
L4   816 L2 AND STEEL

=> s l4 and patent/dt
L5   718 L4 AND PATENT/DT

=> d l5 718

L5   ANSWER 718 OF 718 USPATFULL on STN
AN   80:44867 USPATFULL
TI   Method of manufacturing rolled wire rod
IN   Theis, Klaus, Hamburg, Germany, Federal Republic of
      Forster, Eckehard, Seevetal, Germany, Federal Republic of
      Becher, Wolfram, Neumunster, Germany, Federal Republic of
      Topfer, deceased, Hans-Jorg, late of Buxtehude, Germany, Federal
      Republic of by Marion o pfer, heiress
PA   Hamburger Stahlwerke GmbH, Hamburg, Germany, Federal Republic of
      (non-U.S. corporation)
PI   US 4222257   19800916
AI   US 1977-848911   19771107 (5)
PRAI DE 1977-2717780   19770421
DT   Utility
FS   Granted
LN.CNT 349
INCL INCLM: 072/201.000
      INCLS: 072/700.000; 148/012.000B
NCL   NCLM: 072/201.000
      NCLS: 072/700.000; 148/596.000; 148/664.000
IC   [1]
      ICM   B21B045-02
      ICS   C21D008-06; C21D009-52
      IPCI   B21B0045-02 [ICM,1]; C21D0008-06 [ICS,1]; C21D0009-52 [ICS,1]
      IPCR   B21B0039-20 [I,C*]; B21B0039-28 [I,A]; B21B0045-02 [I,C*];
             B21B0045-02 [I,A]; C21D0008-06 [I,C*]; C21D0008-06 [I,A];
             C22C0038-02 [I,C*]; C22C0038-02 [I,A]; C22C0038-04 [I,C*];
             C22C0038-04 [I,A]
EXF   072/201; 072/364; 072/365; 072/700; 148/12B; 148/12.4; 148/156
CAS INDEXING IS AVAILABLE FOR THIS PATENT.

=> d l5 718 abs

L5   ANSWER 718 OF 718 USPATFULL on STN
AB   A method and apparatus of manufacturing wire rod having a content of

silicon and manganese greater than 1.5% is described, wherein the average final rolling temperature in processing the rod is from 870° C. to 970° C. and the rod is cooled in an extended position. The composition of steels utilized in the method is also described.

CAS INDEXING IS AVAILABLE FOR THIS PATENT.

=> file registry
COST IN U.S. DOLLARS   SINCE FILE   TOTAL
                                                                ENTRY   SESSION
FULL ESTIMATED COST   57.80   91.56

FILE 'REGISTRY' ENTERED AT 19:45:47 ON 31 JAN 2009
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STRUCTURE FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3
DICTIONARY FILE UPDATES: 29 JAN 2009 HIGHEST RN 1097778-52-3

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predicted properties as well as tags indicating availability of
experimental property data in the original document. For information
on property searching in REGISTRY, refer to:

http://www.cas.org/support/stngen/stndoc/properties.html

=> d l2 abs
'ABS' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual
fields or predefined formats. The predefined substance formats
are: (RN = CAS Registry Number)

REG   - RN
SAM   - Index Name, MF, and structure - no RN
FIDE   - All substance data, except sequence data
IDE   - FIDE, but only 50 names
SQIDE   - IDE, plus sequence data
SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used
SQD   - Protein sequence data, includes RN
SQD3   - Same as SQD, but 3-letter amino acid codes are used
SQN   - Protein sequence name information, includes RN

EPROP   - Table of experimental properties
PPROP   - Table of predicted properties
PROP   - EPROP, ETAG, PPROP and SPEC

Any CA File format may be combined with any substance format to
obtain CA references citing the substance. The substance formats
must be cited first. The CA File predefined formats are:

ABS -- Abstract
APPS -- Application and Priority Information
BIB -- CA Accession Number, plus Bibliographic Data
CAN -- CA Accession Number
CBIB -- CA Accession Number, plus Bibliographic Data (compressed)
IND -- Index Data
IPC -- International Patent Classification
PATS -- PI, SO
STD -- BIB, IPC, and NCL

IABS -- ABS, indented, with text labels
IBIB -- BIB, indented, with text labels
ISTD -- STD format, indented

OBIB -------- AN, plus Bibliographic Data (original)
OIBIB ------- OBIB, indented with text labels

SBIB -------- BIB, no citations
SIBIB ------- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when
it is available.
The MAX format is the same as ALL.
The IALL format is the same as ALL with BIB ABS and IND indented,
with text labels.

For additional information, please consult the following help
messages:

HELP DFIELDS -- To see a complete list of individual display fields.
HELP FORMATS -- To see detailed descriptions of the predefined formats.
ENTER DISPLAY FORMAT (IDE):sbib
'SBIB' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual
fields or predefined formats. The predefined substance formats
are: (RN = CAS Registry Number)

REG   - RN
SAM   - Index Name, MF, and structure - no RN
FIDE   - All substance data, except sequence data
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SQIDE   - IDE, plus sequence data
SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used
SQD   - Protein sequence data, includes RN
SQD3   - Same as SQD, but 3-letter amino acid codes are used
SQN   - Protein sequence name information, includes RN

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```
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IABS -- ABS, indented, with text labels
IBIB -- BIB, indented, with text labels
ISTD -- STD format, indented

OBIB -------- AN, plus Bibliographic Data (original)
OIBIB ------- OBIB, indented with text labels

SBIB -------- BIB, no citations
SIBIB ------- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when
it is available.
The MAX format is the same as ALL.
The IALL format is the same as ALL with BIB ABS and IND indented,
with text labels.

For additional information, please consult the following help
messages:

HELP DFIELDS -- To see a complete list of individual display fields.
HELP FORMATS -- To see detailed descriptions of the predefined formats.
ENTER DISPLAY FORMAT (IDE):cancel
'CANCEL' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual
fields or predefined formats.  The predefined substance formats
are:  (RN = CAS Registry Number)

REG    - RN
SAM    - Index Name, MF, and structure - no RN
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SQD    - Protein sequence data, includes RN
SQD3   - Same as SQD, but 3-letter amino acid codes are used
SQN    - Protein sequence name information, includes RN

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PPROP  - Table of predicted properties
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ABS  -- Abstract
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BIB  -- CA Accession Number, plus Bibliographic Data
CAN  -- CA Accession Number
```

```
CBIB -- CA Accession Number, plus Bibliographic Data (compressed)
IND  -- Index Data
IPC  -- International Patent Classification
PATS -- PI, SO
STD  -- BIB, IPC, and NCL


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IBIB -- BIB, indented, with text labels
ISTD -- STD format, indented


OBIB -------- AN, plus Bibliographic Data (original)
OIBIB ------- OBIB, indented with text labels


SBIB -------- BIB, no citations
SIBIB ------- IBIB, no citations


The ALL format gives FIDE BIB ABS IND RE, plus sequence data when
it is available.
The MAX format is the same as ALL.
The IALL format is the same as ALL with BIB ABS and IND indented,
with text labels.


For additional information, please consult the following help
messages:


HELP DFIELDS -- To see a complete list of individual display fields.
HELP FORMATS -- To see detailed descriptions of the predefined formats.
ENTER DISPLAY FORMAT (IDE):exit
'EXIT' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'


The following are valid formats:


Substance information can be displayed by requesting individual
fields or predefined formats.  The predefined substance formats
are:  (RN = CAS Registry Number)


REG    - RN
SAM    - Index Name, MF, and structure - no RN
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SQIDE  - IDE, plus sequence data
SQIDE3 - Same as SQIDE, but 3-letter amino acid codes are used
SQD    - Protein sequence data, includes RN
SQD3   - Same as SQD, but 3-letter amino acid codes are used
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must be cited first.  The CA File predefined formats are:


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APPS -- Application and Priority Information
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CAN  -- CA Accession Number
CBIB -- CA Accession Number, plus Bibliographic Data (compressed)
IND  -- Index Data
IPC  -- International Patent Classification
PATS -- PI, SO
```

```
STD  -- BIB, IPC, and NCL

IABS -- ABS, indented, with text labels
IBIB -- BIB, indented, with text labels
ISTD -- STD format, indented

OBIB -------- AN, plus Bibliographic Data (original)
OIBIB ------- OBIB, indented with text labels

SBIB -------- BIB, no citations
SIBIB ------- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when
it is available.
The MAX format is the same as ALL.
The IALL format is the same as ALL with BIB ABS and IND indented,
with text labels.


For additional information, please consult the following help
messages:

HELP DFIELDS -- To see a complete list of individual display fields.
HELP FORMATS -- To see detailed descriptions of the predefined formats.
ENTER DISPLAY FORMAT (IDE):istd
'ISTD' IS NOT A VALID FORMAT FOR FILE 'REGISTRY'

The following are valid formats:

Substance information can be displayed by requesting individual
fields or predefined formats.  The predefined substance formats
are:  (RN = CAS Registry Number)

REG     - RN
SAM     - Index Name, MF, and structure - no RN
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IDE     - FIDE, but only 50 names
SQIDE   - IDE, plus sequence data
SQIDE3  - Same as SQIDE, but 3-letter amino acid codes are used
SQD     - Protein sequence data, includes RN
SQD3    - Same as SQD, but 3-letter amino acid codes are used
SQN     - Protein sequence name information, includes RN

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PROP    - EPROP, ETAG, PPROP and SPEC

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CAN  -- CA Accession Number
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IPC  -- International Patent Classification
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IABS -- ABS, indented, with text labels
IBIB -- BIB, indented, with text labels
```

```
ISTD -- STD format, indented

OBIB -------- AN, plus Bibliographic Data (original)
OIBIB ------- OBIB, indented with text labels

SBIB -------- BIB, no citations
SIBIB ------- IBIB, no citations

The ALL format gives FIDE BIB ABS IND RE, plus sequence data when
it is available.
The MAX format is the same as ALL.
The IALL format is the same as ALL with BIB ABS and IND indented,
with text labels.

For additional information, please consult the following help
messages:

HELP DFIELDS -- To see a complete list of individual display fields.
HELP FORMATS -- To see detailed descriptions of the predefined formats.
ENTER DISPLAY FORMAT (IDE):reg
1          RN           1093218-16-6  REGISTRY


=> file registry
COST IN U.S. DOLLARS                              SINCE FILE       TOTAL
                                                     ENTRY       SESSION
FULL ESTIMATED COST                                   1.21         92.77

FILE 'REGISTRY' ENTERED AT 19:46:44 ON 31 JAN 2009
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DICTIONARY FILE UPDATES:  29 JAN 2009  HIGHEST RN 1097778-52-3

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on property searching in REGISTRY, refer to:

http://www.cas.org/support/stngen/stndoc/properties.html

=> d l2 2

L2   ANSWER 2 OF 692  REGISTRY  COPYRIGHT 2009 ACS on STN
RN   1093216-10-4  REGISTRY
ED   Entered STN:  12 Jan 2009
CN   INDEX NAME NOT YET ASSIGNED
MF   C . Al . Bi . Co . Cr . Cu . Fe . Ge . Mn . Mo . Ni . P . Sb . Se . Si .
     Sn . Te . Unspecified . W
CI   AYS
```

```
SR    CA
LC    STN Files:   CA, CAPLUS

    Component         Component      Component
                       Percent      Registry Number
================+==============+=================
Fe              48  -  98           7439-89-6
Cr               0  -  15           7440-47-3
Cu               0  -   8           7440-50-8
Al             2.5  -   6           7429-90-5
Co               0  -   4           7440-48-4
Mo               0  -   4           7439-98-7
W                0  -   4           7440-33-7
Si               0  - 3.5           7440-21-3
Mn               0  -   3           7439-96-5
Ni               0  -   2           7440-02-0
Ge               0  - 0.5           7440-56-4
Sb               0  - 0.5           7440-36-0
Sn               0  - 0.5           7440-31-5
P                0  - 0.3           7723-14-0
Se               0  - 0.3           7782-49-2
Te               0  - 0.3          13494-80-9
Bi               0  - 0.2           7440-69-9
C                0  - 0.1           7440-44-0
Misch metal      0  - 0.1           8049-20-5

              3 REFERENCES IN FILE CA (1907 TO DATE)
              3 REFERENCES IN FILE CAPLUS (1907 TO DATE)


=> file registry
COST IN U.S. DOLLARS                          SINCE FILE      TOTAL
                                                ENTRY        SESSION
FULL ESTIMATED COST                              2.53         95.30

FILE 'REGISTRY' ENTERED AT 19:47:07 ON 31 JAN 2009
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STRUCTURE FILE UPDATES:   29 JAN 2009  HIGHEST RN 1097778-52-3
DICTIONARY FILE UPDATES:  29 JAN 2009  HIGHEST RN 1097778-52-3

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REGISTRY includes numerically searchable data for experimental and
predicted properties as well as tags indicating availability of
experimental property data in the original document.  For information
on property searching in REGISTRY, refer to:

http://www.cas.org/support/stngen/stndoc/properties.html

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac
and 0-0.1 S/mac and 80-100 Fe/mac
```

```
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
               (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
               (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
               (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
               (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
               (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
               (0-0.3/MAC (P) CU/MAC)
        336565 0-0.1/MAC
         20543 BI/MAC
          3203 0-0.1 BI/MAC
               (0-0.1/MAC (P) BI/MAC)
        434955 0-0.2/MAC
         25740 PB/MAC
          6327 0-0.2 PB/MAC
               (0-0.2/MAC (P) PB/MAC)
        475715 0-0.3/MAC
        341765 NI/MAC
         53982 0-0.3 NI/MAC
               (0-0.3/MAC (P) NI/MAC)
        336565 0-0.1/MAC
         26299 S/MAC
         17353 0-0.1 S/MAC
               (0-0.1/MAC (P) S/MAC)
        524182 80-100/MAC
        558510 FE/MAC
        272393 80-100 FE/MAC
               (80-100/MAC (P) FE/MAC)
L6         19 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
               CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
               0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 0-0.1 S/MAC AND 80-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac
and 0-0.1 S/mac and 80-95 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
               (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
               (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
```

```
                     (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
                     (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
                     (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
                     (0-0.3/MAC (P) CU/MAC)
        336565 0-0.1/MAC
         20543 BI/MAC
          3203 0-0.1 BI/MAC
                     (0-0.1/MAC (P) BI/MAC)
        434955 0-0.2/MAC
         25740 PB/MAC
          6327 0-0.2 PB/MAC
                     (0-0.2/MAC (P) PB/MAC)
        475715 0-0.3/MAC
        341765 NI/MAC
         53982 0-0.3 NI/MAC
                     (0-0.3/MAC (P) NI/MAC)
        336565 0-0.1/MAC
         26299 S/MAC
         17353 0-0.1 S/MAC
                     (0-0.1/MAC (P) S/MAC)
        318951 80-95/MAC
        558510 FE/MAC
        147519 80-95 FE/MAC
                     (80-95/MAC (P) FE/MAC)
L7         19 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
              CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
              0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 0-0.1 S/MAC AND 80-95 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac
and 0-0.1 S/mac and 70-100 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
                     (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
                     (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
                     (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
                     (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
                     (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
```

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         60826 0-0.3 CU/MAC
               (0-0.3/MAC (P) CU/MAC)
        336565 0-0.1/MAC
         20543 BI/MAC
          3203 0-0.1 BI/MAC
               (0-0.1/MAC (P) BI/MAC)
        434955 0-0.2/MAC
         25740 PB/MAC
          6327 0-0.2 PB/MAC
               (0-0.2/MAC (P) PB/MAC)
        475715 0-0.3/MAC
        341765 NI/MAC
         53982 0-0.3 NI/MAC
               (0-0.3/MAC (P) NI/MAC)
        336565 0-0.1/MAC
         26299 S/MAC
         17353 0-0.1 S/MAC
               (0-0.1/MAC (P) S/MAC)
        639931 70-100/MAC
        558510 FE/MAC
        328593 70-100 FE/MAC
               (70-100/MAC (P) FE/MAC)
L8        19 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
             CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
             0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 0-0.1 S/MAC AND 70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 0-0.3 ni/mac
and 70-100 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
               (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
               (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
               (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
               (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
               (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
               (0-0.3/MAC (P) CU/MAC)
        336565 0-0.1/MAC
         20543 BI/MAC
          3203 0-0.1 BI/MAC
               (0-0.1/MAC (P) BI/MAC)
        434955 0-0.2/MAC
         25740 PB/MAC
          6327 0-0.2 PB/MAC
               (0-0.2/MAC (P) PB/MAC)
        475715 0-0.3/MAC
```

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        341765 NI/MAC
         53982 0-0.3 NI/MAC
                (0-0.3/MAC (P) NI/MAC)
        639931 70-100/MAC
        558510 FE/MAC
        328593 70-100 FE/MAC
                (70-100/MAC (P) FE/MAC)
L9          23 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
                CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
                0-0.2 PB/MAC AND 0-0.3 NI/MAC AND 70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 0-0.2 Pb/mac and 70-100 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
                (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
                (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
                (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
                (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
                (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
                (0-0.3/MAC (P) CU/MAC)
        336565 0-0.1/MAC
         20543 BI/MAC
          3203 0-0.1 BI/MAC
                (0-0.1/MAC (P) BI/MAC)
        434955 0-0.2/MAC
         25740 PB/MAC
          6327 0-0.2 PB/MAC
                (0-0.2/MAC (P) PB/MAC)
        639931 70-100/MAC
        558510 FE/MAC
        328593 70-100 FE/MAC
                (70-100/MAC (P) FE/MAC)
L10         24 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
                CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
                0-0.2 PB/MAC AND 70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 70-100 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
                (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
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                 (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
                 (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
                 (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
                 (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
                 (0-0.3/MAC (P) CU/MAC)
        336565 0-0.1/MAC
         20543 BI/MAC
          3203 0-0.1 BI/MAC
                 (0-0.1/MAC (P) BI/MAC)
        639931 70-100/MAC
        558510 FE/MAC
        328593 70-100 FE/MAC
                 (70-100/MAC (P) FE/MAC)
L11         35 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
                 CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
                 70-100 FE/MAC

=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 70-100 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
                 (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
                 (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
                 (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
                 (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
                 (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
                 (0-0.3/MAC (P) CU/MAC)
        639931 70-100/MAC
        558510 FE/MAC
        328593 70-100 FE/MAC
                 (70-100/MAC (P) FE/MAC)
L12        688 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
                 CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 70-100 FE/MAC
```

```
=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 0-0.1 Bi/mac and 70-100 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
               (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
               (1.0-1.5/MAC (P) MN/MAC)
        356971 0.8-1.2/MAC
        420616 SI/MAC
         68891 0.8-1.2 SI/MAC
               (0.8-1.2/MAC (P) SI/MAC)
        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
               (1.0-1.4/MAC (P) CR/MAC)
        475538 0.1-0.3/MAC
        207475 MO/MAC
         53856 0.1-0.3 MO/MAC
               (0.1-0.3/MAC (P) MO/MAC)
        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
               (0-0.3/MAC (P) CU/MAC)
        336565 0-0.1/MAC
         20543 BI/MAC
          3203 0-0.1 BI/MAC
               (0-0.1/MAC (P) BI/MAC)
        639931 70-100/MAC
        558510 FE/MAC
        328593 70-100 FE/MAC
               (70-100/MAC (P) FE/MAC)
L13         35 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
               CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 0-0.1 BI/MAC AND
               70-100 FE/MAC


=> file caplus, uspatfull, scisearch
COST IN U.S. DOLLARS                              SINCE FILE      TOTAL
                                                     ENTRY       SESSION
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L14         43 L13

=> d l14 all

L14  ANSWER 1 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
AN   2009:27896  CAPLUS
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DN   150:81420
ED   Entered STN:  09 Jan 2009
TI   Method for manufacture of nondirectional electromagnetic steel sheets for
     rotors
IN   Tanaka, Ichiro; Yashiki, Hiroyoshi; Takamaru, Hiroki; Fujita, Kaoru
PA   Sumitomo Metal Industries Ltd., Japan
SO   Jpn. Kokai Tokkyo Koho, 19pp.
     CODEN: JKXXAF
DT   Patent
LA   Japanese
CC   55-11 (Ferrous Metals and Alloys)
FAN.CNT 1
     PATENT NO.          KIND  DATE      APPLICATION NO.       DATE
     --------------      ----  --------  --------------------  --------
PI   JP 2009001887       A     20090108  JP 2007-165962        20070625
PRAI JP 2007-165962            20070625
CLASS
 PATENT NO.     CLASS  PATENT FAMILY CLASSIFICATION CODES
 -------------  -----  -------------------------------------------
 JP 2009001887  IPCI   C21D0008-12 [I,A]; B21B0003-02 [I,A]; H01F0001-16
                       [I,A]; H01F0001-12 [I,C*]; H01F0041-02 [I,A];
                       C22C0038-00 [N,A]; C22C0038-60 [N,A]
                FTERM  4K033/AA01; 4K033/CA01; 4K033/CA02; 4K033/CA03;
                       4K033/CA04; 4K033/CA05; 4K033/CA06; 4K033/CA07;
                       4K033/CA08; 4K033/CA09; 4K033/CA10; 4K033/EA02;
                       4K033/FA01; 4K033/FA03; 4K033/FA10; 4K033/FA12;
                       4K033/GA00; 4K033/HA01; 4K033/HA03; 4K033/JA01;
                       4K033/KA00; 5E041/AA02; 5E041/CA04; 5E041/HB11;
                       5E041/NN01; 5E062/AA06; 5E062/AC15
AB   Slabs or ingots of steels consisting of C ≤0.06, Si ≤3.5, Mn
     0.05-3.0, Al >2.5 and ≤6.0, P ≤0.30, S ≤0.04, N
     ≤0.02, Nb >0.02 weight%, and balance Fe and satisfying 0 <Nb/93 +
     Zr/91 + Ti/48 + V/51 - (C/12 + N/14) <5 + 10-3 (the element symbols
     indicate their weight% contents) are hot rolled, cold rolled, at least once
     with in-between process annealing, into sheets of thickness 0.15-0.80 mm
     and tensile strength ≥850 MPa, and then soaked at
     ≤820° to give the title sheets.  The steels may also contain
     Cu 0.01-8.0, Ni 0.01-2.0, Cr 0.01-15.0, Mo 0.005-4.0, Co 0.01-4.0, W
     0.01-4.0, Sn ≤0.5, Sb ≤0.5, Se ≤0.3, Bi ≤0.2,
     Ge ≤0.5, Te ≤0.3, B ≤0.01, Ca ≤0.03, Mg
     ≤0.02, and/or rare earth metals ≤0.1 weight%.  Rotors with
     decreased weight can be prepared from the sheets.
ST   nondirectional electromagnetic steel sheet rolling rotor
IT   Rolling (metals)
         (hot; manufacture of nondirectional electromagnetic steel sheets for rotors
         by hot and cold rolling, process annealing, and soaking)
IT   Cold rolling
         (manufacture of nondirectional electromagnetic steel sheets for rotors by
         hot and cold rolling, process annealing, and soaking)
IT   Annealing
         (process; manufacture of nondirectional electromagnetic steel sheets for
         rotors by hot and cold rolling, process annealing, and soaking)
IT   Electric motors
         (rotors; manufacture of nondirectional electromagnetic steel sheets for
         rotors by hot and cold rolling, process annealing, and soaking)
IT   Heat treatment
         (soaking; manufacture of nondirectional electromagnetic steel sheets for
         rotors by hot and cold rolling, process annealing, and soaking)
IT   1093215-97-4   1093215-98-5   1093215-99-6   1093216-01-3   1093216-02-4
     1093216-04-6   1093216-05-7   1093216-06-8   1093216-07-9
     1093216-10-4
     RL: PEP (Physical, engineering or chemical process); TEM (Technical or
```

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      engineered material use); PROC (Process); USES (Uses)
         (manufacture of nondirectional electromagnetic steel sheets for rotors by
         hot and cold rolling, process annealing, and soaking)
IT    7439-95-4, Magnesium, uses    7440-42-8, Boron, uses    7440-70-2, Calcium,
      uses
      RL: MOA (Modifier or additive use); USES (Uses)
         (microalloying element; manufacture of nondirectional electromagnetic steel
         sheets for rotors by hot and cold rolling, process annealing, and
         soaking)


=> d l14 pi 1

L14   ANSWER 1 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2009001887      A    20090108  JP 2007-165962       20070625


=> d l14 pi 1-43

L14   ANSWER 1 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2009001887      A    20090108  JP 2007-165962       20070625

L14   ANSWER 2 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2009001864      A    20090108  JP 2007-163851       20070621

L14   ANSWER 3 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2008308727      A    20081225  JP 2007-157349       20070614

L14   ANSWER 4 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2008308704      A    20081225  JP 2007-154899       20070612

L14   ANSWER 5 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2008149340      A    20080703  JP 2006-338791       20061215

L14   ANSWER 6 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2008013788      A    20080124  JP 2006-183512       20060703

L14   ANSWER 7 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2007031787      A    20070208  JP 2005-217453       20050727

L14   ANSWER 8 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.        KIND  DATE      APPLICATION NO.      DATE
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PI    WO 2007007423      A1   20070118  WO 2005-JP22368      20051206
         W:  AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH,
             CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD,
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              GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ,
              LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ,
              NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG,
              SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
              YU, ZA, ZM, ZW
          RW: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE,
              IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR, BF, BJ,
              CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG, BW, GH,
              GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY,
              KG, KZ, MD, RU, TJ, TM
    JP 2007016278        A      20070125    JP 2005-198794            20050707
    JP 2007023351        A      20070201    JP 2005-208597            20050719
    JP 2007031755        A      20070208    JP 2005-214625            20050725
    CN 101218362         A      20080709    CN 2005-80050983          20080104
    KR 2008027913        A      20080328    KR 2008-702741            20080201
    IN 2008CN00647       A      20081128    IN 2008-CN647             20080207


L14  ANSWER 9 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE       APPLICATION NO.          DATE
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PI   JP 2006348321        A      20061228    JP 2005-173112            20050614


L14  ANSWER 10 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE       APPLICATION NO.          DATE
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PI   JP 2006299296        A      20061102    JP 2005-118366            20050415


L14  ANSWER 11 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE       APPLICATION NO.          DATE
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PI   JP 2006249457        A      20060921    JP 2005-64316             20050308


L14  ANSWER 12 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE       APPLICATION NO.          DATE
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PI   JP 2006206967        A      20060810    JP 2005-21019             20050128


L14  ANSWER 13 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE       APPLICATION NO.          DATE
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PI   JP 2006037177        A      20060209    JP 2004-220223            20040728


L14  ANSWER 14 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE       APPLICATION NO.          DATE
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PI   FR 2868083           A1     20050930    FR 2004-3038              20040324
     FR 2868083           B1     20060721
     AU 2005232002        A1     20051020    AU 2005-232002            20050321
     CA 2559562           A1     20051020    CA 2005-2559562           20050321
     WO 2005098070        A2     20051020    WO 2005-FR684             20050321
     WO 2005098070        A3     20061005
          W:  AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH,
              CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD,
              GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
              LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI,
              NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM,
              SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW
          RW: BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM,
              AZ, BY, KG, KZ, MD, RU, TJ, TM, AT, BE, BG, CH, CY, CZ, DE, DK,
              EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT,
              RO, SE, SI, SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML,
              MR, NE, SN, TD, TG
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      EP 1727919           A2      20061206    EP 2005-742733        20050321
        R:  AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE,
            IS, IT, LI, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR, AL, BA,
            HR, LV, MK, YU
      CN 1950533            A       20070418    CN 2005-80014026      20050321
      BR 2005008776         A       20070904    BR 2005-8776          20050321
      JP 2007530780         T       20071101    JP 2007-504447        20050321
      US 20070193658        A1      20070823    US 2006-593463        20060919
      MX 2006010816         A       20061120    MX 2006-10816         20060921
      IN 2006CN03491        A       20070615    IN 2006-CN3491        20060922
      KR 2007021185         A       20070222    KR 2006-722040        20061024

L14  ANSWER 15 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2005220423         A       20050818    JP 2004-30993         20040206

L14  ANSWER 16 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2005059096         A       20050310    JP 2004-199624        20040706

L14  ANSWER 17 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2004292929         A       20041021    JP 2003-89959         20030328
     JP 3912308            B2      20070509

L14  ANSWER 18 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2004025205         A       20040129    JP 2002-182228        20020621
     JP 3789856            B2      20060628

L14  ANSWER 19 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   EP 1335035            A1      20030813    EP 2003-250686        20030203
     EP 1335035            B1      20050420
        R:  AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT,
            IE, SI, LT, LV, FI, RO, MK, CY, AL, TR, BG, CZ, EE, HU, SK
     JP 2003226933         A       20030815    JP 2002-26368         20020204
     JP 3758581            B2      20060322
     TW 228149             B       20050221    TW 2003-92102006      20030129
     CN 1436875            A       20030820    CN 2003-103453        20030130
     CN 1210432            C       20050713
     US 20030152476        A1      20030814    US 2003-357419        20030204

L14  ANSWER 20 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2003147481         A       20030521    JP 2001-349097        20011114
     JP 3851146            B2      20061129

L14  ANSWER 21 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2003147479         A       20030521    JP 2001-349095        20011114
     JP 3901994            B2      20070404

L14  ANSWER 22 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.           KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2003147435       A       20030521    JP 2001-349098          20011114
     JP 3747365          B2      20060222

L14  ANSWER 23 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
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PI   JP 2003147482       A       20030521    JP 2001-349100          20011114
     JP 3851147          B2      20061129

L14  ANSWER 24 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   JP 2003147436       A       20030521    JP 2001-349099          20011114
     JP 3750737          B2      20060301

L14  ANSWER 25 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   FR 2830261          A1      20030404    FR 2002-11966           20020927
     JP 2003183770       A       20030703    JP 2002-112457          20020415
     JP 3468239          B2      20031117
     CN 1410581          A       20030416    CN 2002-144079          20020930
     CN 1180113          C       20041215
     US 20030084965      A1      20030508    US 2002-259744          20020930
     US 6838048          B2      20050104

L14  ANSWER 26 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   JP 2003073735       A       20030312    JP 2001-258353          20010828
     JP 4213370          B2      20090121

L14  ANSWER 27 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   JP 2001234279       A       20010828    JP 2000-44821           20000222

L14  ANSWER 28 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   JP 2001192765       A       20010717    JP 2000-193780          20000628
     JP 3253293          B2      20020204
     EP 1167561          A2      20020102    EP 2000-125344          20001130
        R:  AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT,
            IE, SI, LT, LV, FI, RO

L14  ANSWER 29 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   JP 2001152278       A       20010605    JP 1999-331045          19991122

L14  ANSWER 30 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   JP 2001131684       A       20010515    JP 1999-314366          19991104

L14  ANSWER 31 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND    DATE        APPLICATION NO.         DATE
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PI   JP 2000273574       A       20001003    JP 1999-81629           19990325
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L14  ANSWER 32 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2000219936      A     20000808   JP 1999-23459          19990201


L14  ANSWER 33 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
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PI   WO 2000044953      A1    20000803   WO 2000-JP369          20000125
        W:  CA, CN, KR, US
        RW: AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL,
            PT, SE
     CA 2323952         A1    20000803   CA 2000-2323952        20000125
     EP 1069198         A1    20010117   EP 2000-900930         20000125
        R:  AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT,
            IE, FI
     CN 1113973         C     20030709   CN 2000-800083         20000125
     JP 2000282172      A     20001010   JP 2000-18101          20000127
     JP 3680674         B2    20050810
     JP 2001214241      A     20010807   JP 2000-204882         20000706
     JP 3680708         B2    20050810
     US 6475305         B1    20021105   US 2000-669552         20000926


L14  ANSWER 34 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
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PI   JP 2000026933      A     20000125   JP 1998-192878         19980708
     JP 3893756         B2    20070314


L14  ANSWER 35 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
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PI   JP 11001743        A     19990106   JP 1998-52103          19980304
     JP 3489656         B2    20040126


L14  ANSWER 36 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
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PI   JP 10152754        A     19980609   JP 1997-249242         19970912
     JP 3724142         B2    20051207


L14  ANSWER 37 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
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PI   JP 09025541        A     19970128   JP 1995-175318         19950712


L14  ANSWER 38 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
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PI   JP 07150293        A     19950613   JP 1993-296667         19931126


L14  ANSWER 39 OF 43  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE       APPLICATION NO.        DATE
     --------------    ----   --------   --------------------   --------
PI   JP 06248341        A     19940906   JP 1993-33687          19930223


L14  ANSWER 40 OF 43  USPATFULL on STN
PI   US 20070193658     A1    20070823


L14  ANSWER 41 OF 43  USPATFULL on STN
PI   US 20030152476     A1    20030814
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L14  ANSWER 42 OF 43  USPATFULL on STN
PI     US 20030084965     A1  20030508
       US 6838048         B2  20050104

L14  ANSWER 43 OF 43  USPATFULL on STN
PI     US 6475305         B1  20021105


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COST IN U.S. DOLLARS                              SINCE FILE      TOTAL
                                                     ENTRY      SESSION
FULL ESTIMATED COST                                  63.69       563.60

DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)        SINCE FILE      TOTAL
                                                     ENTRY      SESSION
CA SUBSCRIBER PRICE                                  -0.82        -0.82

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=> s 0.1-0.3 C/mac and 1.0-1.5 Mn/mac and 0.8-1.2 Si/mac and 1.0-1.4 Cr/mac and
0.1-0.3 Mo/mac and 0-0.3 Cu/mac and 70-100 Fe/mac
        475538 0.1-0.3/MAC
        273599 C/MAC
        145576 0.1-0.3 C/MAC
               (0.1-0.3/MAC (P) C/MAC)
        358258 1.0-1.5/MAC
        393253 MN/MAC
        102131 1.0-1.5 MN/MAC
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        323205 1.0-1.4/MAC
        345555 CR/MAC
         32082 1.0-1.4 CR/MAC
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        475538 0.1-0.3/MAC
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        475715 0-0.3/MAC
        245265 CU/MAC
         60826 0-0.3 CU/MAC
               (0-0.3/MAC (P) CU/MAC)
        639931 70-100/MAC
        558510 FE/MAC
        328593 70-100 FE/MAC
               (70-100/MAC (P) FE/MAC)
L15        688 0.1-0.3 C/MAC AND 1.0-1.5 MN/MAC AND 0.8-1.2 SI/MAC AND 1.0-1.4
               CR/MAC AND 0.1-0.3 MO/MAC AND 0-0.3 CU/MAC AND 70-100 FE/MAC


=> file caplus, uspatfull, scisearch
COST IN U.S. DOLLARS                          SINCE FILE    TOTAL
                                                ENTRY      SESSION
FULL ESTIMATED COST                             37.93       601.53

DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)    SINCE FILE    TOTAL
                                                ENTRY      SESSION
CA SUBSCRIBER PRICE                              0.00       -0.82
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CA INDEXING COPYRIGHT (C) 2009 AMERICAN CHEMICAL SOCIETY (ACS)

FILE 'SCISEARCH' ENTERED AT 19:52:46 ON 31 JAN 2009
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```
=> s l15 and steel
'MAC' IS NOT A VALID FIELD CODE
L16        816 L15 AND STEEL

=> s l16 and (niobium or columbium or nb)
L17        523 L16 AND (NIOBIUM OR COLUMBIUM OR NB)

=> s l17 and (copper or cu)
L18        484 L17 AND (COPPER OR CU)

=> s steel and (carbon or c) and (manganese or mn) and (silicon or si) and (sulfur
or sulphur or s) and (phosphorus or p) and (nickel or ni) and (chromium or cr) and
(molybdenum or mo) and (copper or cu) and (aluminum or aluminium or al) and
(niobium or columbium or nb or cb)
L19       9168 STEEL AND (CARBON OR C) AND (MANGANESE OR MN) AND (SILICON OR
               SI) AND (SULFUR OR SULPHUR OR S) AND (PHOSPHORUS OR P) AND (NICK
               EL OR NI) AND (CHROMIUM OR CR) AND (MOLYBDENUM OR MO) AND (COPPE
               R OR CU) AND (ALUMINUM OR ALUMINIUM OR AL) AND (NIOBIUM OR COLUM
               BIUM OR NB OR CB)

=> s l19 and (nitrogen or n) and (bismuth or bi) and (selenium or se) and (calcium
or ca) and (iron or fe)
L20        878 L19 AND (NITROGEN OR N) AND (BISMUTH OR BI) AND (SELENIUM OR
               SE) AND (CALCIUM OR CA) AND (IRON OR FE)

=> s l20 and (tellerium or te)
L21        426 L20 AND (TELLERIUM OR TE)

=> s l21 and (hardenability or jominy)
```

=> d 122 all

AN   2008:283040   USPATFULL
TI   Component for Machine Structure, Method of Producing the Same and
      Material for Induction Hardening
IN   Hayashi, Toru, Okayama, JAPAN
      Ohmori, Yasuhiro, Okayama, JAPAN
      Kurosawa, Nobutaka, Okayama, JAPAN
      Matsuzaki, Akihiro, Chiba, JAPAN
      Toyooka, Takaaki, Okayama, JAPAN
      Yamada, Katsumi, Kanagawa, JAPAN
PA   JFE STEEL CORPORATION, Chiyoda-ku, Tokyo, JAPAN (non-U.S. corporation)
PI   US 20080247900   A1   20081009
AI   US 2005-587731   A1   20050705 (11)
      WO 2005-JP12397   20050705
                              20061027 PCT 371 date
PRAI WO 2005-JP10200   20040716
DT   Utility
FS   APPLICATION
LREP FRISHAUF, HOLTZ, GOODMAN & CHICK, PC, 220 Fifth Avenue, 16TH Floor, NEW
      YORK, NY, 10001-7708, US
CLMN Number of Claims: 38
ECL   Exemplary Claim: 1
DRWN 5 Drawing Page(s)
AB   There is provided a component for machine structure having a hardened
      layer through an induction hardening in at least a part thereof, and
      more improving fatigue strengths as compared with the conventional ones,
      in which the hardened layer has a hardness Hv of not less than 750 and
      an average grain size of prior austenite grains is not more than 7 μm
      over a full thickness of the hardened layer.

SUMM TECHNICAL FIELD

      This invention relates to a component for machine structure provided in
      at least a part thereof with a hardened layer through an induction
      hardening. As the component for machine structure may be mentioned a
      drive shaft for an automobile, an input shaft, an output shaft, a
      crankshaft, inner and outer wheels of a constant velocity joint, a hub,
      a gear and so on.

      RELATED ART

      Heretofore, in the components for machine structure such as a drive
      shaft for an automobile, a constant velocity joint and the like, it is
      usual to ensure fatigue strengths as a characteristic of the component
      for machine structure such as torsional fatigue strength, bending
      fatigue strength, rolling fatigue strength, slip rolling fatigue
      strength and the like by working a hot rolled steel bar into a
      given shape through hot forging, cutting, cold forging and the like and
      then subjecting to induction hardening and tempering.

      On the other hand, it is strongly demanded to reduce the weight of the
      component for the automobile from recent environmental problems. From
      this viewpoint, it is demanded to more improve the fatigue strengths in
      the components for the automobile.

      As the means for improving the fatigue strengths as mentioned above,
      there are proposed various methods up to now.

For example, it is considered to increase the hardening depth in the induction hardening for improving the torsional fatigue strength. However, the fatigue strength is saturated at a certain depth even in the increase of the hardening depth.

Also, it is effective to improve the grain boundary strength for the improvement of the torsional fatigue strength. From this viewpoint, there is proposed a technique of refining a particle size of prior austenite by dispersing TiC (see, for example, Patent Document 1).

According to the technique disclosed in the above Patent Document 1, it is attempted to refine the particle size of prior austenite by dispersing a great amount of fine TiC in the heating of the induction hardening, so that it is required to solid-solute TiC prior to the hardening, and hence it is adopted to conduct the heating above 1100° C. at the hot rolling step. For this end, it is required to raise the heating temperature in the hot rolling, so that there is a problem that the productivity is poor.

Also, there is still a problem that the recent demand on the fatigue strengths is not sufficiently satisfied even by the technique disclosed in Patent Document 1.

Furthermore, Patent Document 2 proposes a shaft component for machine structure wherein the torsional fatigue strength is improved by restricting a ratio of a depth of the hardened layer CD to a radius of the induction hardened shaft component R (CD/R) to 0.3-0.7 and further controlling a value A defined with CD/R, austenite particle size γf from a surface to 1 mm after the induction hardening, average Vickers hardness Hv to (CD/R)=0.1 as induction-hardened and average Vickers hardness in a shaft central portion after the induction hardening to a predetermined range.

However, there is a limit in the improvement of the fatigue properties even in the control of CD/R, so that the recent demand on the torsional fatigue strength could not be yet satisfied.

Patent Document 1: JP-A-2000-154819 (claims, paragraph [0008])
Patent Document 2: JP-A-H08-53714 (claims)

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

It is an object of the invention to provide a component for machine structure capable of more improving the fatigue strength as compared with the conventional ones after the induction hardening and a method of producing the same as well as a material for the induction hardening.

Means for Solving Problems

The inventors have made various studies in order to effectively improve the fatigue strengths of steel materials through the induction hardening. Particularly, the inventors have noticed the torsional fatigue strength as a typical example of the fatigue strengths and made detail examinations thereon, and obtained the following discoveries.

(i) Although the fatigue strength is improved by increasing a transgranular strength of a hardened layer through the induction hardening or a hardness thereof, when the hardness is increased to not less than 750 as a Vickers hardness Hv, the fracture migrates from the transgranular fracture to a fracture at a grain boundary of prior austenite, so that the fatigue strength is not improved even if the hardness is increased over the above value.

(ii) The strength of the prior austenite grain boundary can be improved by refining the grain size of the prior austenite in the hardened layer through the induction hardening, and hence the increase of the fatigue strength can be attained in accordance with the increase of the hardness by making the average grain size of the prior austenite to not more than 7 μm even if the hardness Hv is not less than 750.

(iii) In order than the hardness Hv of the hardened layer is not less than 750, it is effective to increase contents of one or more of C, Si and P in the starting material, while in order to refine the grain size of the prior austenite in the hardened layer through the induction hardening, it is effective that Mo, B and Ti are included in the starting material and the microstructure prior to the induction hardening is made a fine bainite or martensite introduced with a worked strain through cold working and further that a rapid heating is conducted in the induction hardening and a heating temperature is made low and further a residence time above 800° C. is made short.

(iv) Although the tempering is usually carried out as another means for increasing the strength after the induction hardening, it is possible to increase the transgranular strength by omitting this means.

The invention is based on the above knowledge.

That is, the thrust and construction of the invention are as follows.

1. A component for machine structure characterized by comprising a hardened layer through an induction hardening in at least a part thereof, in which the hardened layer has a hardness Hv of not less than 750 and an average grain size of prior austenite grains is not more than 7 μm over a full thickness of the hardened layer.

2. A component for machine structure according to the item 1, which has a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3):

    C>0.7 mass %   (1)

    Si>1.1 mass %   (2)

    P>0.02 mass %   (3)

3. A component for machine structure according to item 2, wherein a content of Al in the chemical composition is Al: 0.005-0.25 mass %.

4. A component for machine structure according to item 2 or 3, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

5. A component for machine structure according to any one of items 2 to 4, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more

than 0.1 mass %, Se: not more than 0.1 mass %, Bi:
not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more
than 0.01 mass % and REM: not more than 0.1 mass %.

6. A component for machine structure according to item 1, which has a
chemical composition comprising C: 0.3-1.5 mass %, Si
: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more
than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %,
B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and
P: not more than 0.10 mass % and the remainder being Fe
and inevitable impurities in which the hardened layer is not subjected
to a tempering.

7. A component for machine structure according to item 6, wherein a
content of Al in the composition is Al: 0.005-0.25
mass %.

8. A component for machine structure according to item 6 or 7, wherein
the chemical composition further contains one or more selected from
Cr: not more than 2.5 mass %, Cu: not more than 1.0
mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0
mass %, Nb: not more than 0.1 mass %, V: not more than 0.5
mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and
Sb: not more than 0.015 mass %.

9. A component for machine structure according to any one of items 6 to
8, wherein the chemical composition further contains one or more
selected from W: not more than 1.0 mass %, Ca: not more than
0.005 mass %, Mg: not more than 0.005 mass %, Te: not more
than 0.1 mass %, Se: not more than 0.1 mass %, Bi:
not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more
than 0.01 mass % and REM: not more than 0.1 mass %.

10. A component for machine structure according to any one of items 2 to
9, wherein Mo-based precipitate is dispersed in an amount of
not less than 500 per 1 μm.sup.3 and an average particle size of the
Mo-based precipitate is not more than 20 nm.

11. A method of producing a component for machine structure by
subjecting at least a part of a starting material having a chemical
composition comprising C: 0.3-1.5 mass %, Si:
0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more
than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %,
B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and
P: not more than 0.10 mass %, and the remainder being Fe
and inevitable impurities, and satisfying at least one of the following
equations (1)-(3):

   C>0.7 mass %   (1)

   Si>1.1 mass %   (2)

   P>0.02 mass %   (3)

to an induction hardening at least once, characterized in that either or
both of bainite structure and martensite structure in steel
microstructure of the starting material prior to the induction hardening
is adjusted to not less than 10 volume %, and a ultimate temperature of
the induction hardening is not higher than 1000° C.

12. A method of producing a component for machine structure according to
item 11, wherein a content of Al in the chemical composition

is Al: 0.005-0.25 mass %.

13. A method of producing a component for machine structure according to item 11 or 12, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

14. A method of producing a component for machine structure according to any one of items 11 to 13, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

15. A material for induction hardening used for the formation of a component for machine structure having in at least a part of its surface a hardened layer with an average grain size of prior austenite of not more than 7 μm through an induction hardening, characterized by having a chemical composition comprising C: 0.3-1.5 mass %, Si: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3):

$$C > 0.7 \text{ mass \%} \quad (1)$$

$$Si > 1.1 \text{ mass \%} \quad (2)$$

$$P > 0.02 \text{ mass \%} \quad (3)$$

and having a steel microstructure in which either or both of bainite structure and martensite structure is not less than 10 volume %.

16. A material for induction hardening according to item 15, wherein a content of Al in the composition is Al: 0.005-0.25 mass %.

17. A material for induction hardening according to item 15 or 16, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

18. A material for induction hardening according to any one of items 15 to 17, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

19. A material for induction hardening according to any one of items 15 to 18, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1 μm.sup.3 and an average particle size of

the Mo-based precipitate is not more than 20 nm.

Effect of the Invention

According to the invention, there can be stably obtained components for machine structure having excellent fatigue properties exemplifying torsional fatigue property and rolling fatigue property, and hence there are developed considerable effects on the demands such as weight reduction of automobile parts and the like.

DRWD BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graph showing an influence of a heating temperature in an induction hardening on a grain size of prior austenite in a hardened layer with respect to Mo-added steel and Mo -free steel;

FIG. 2 is a transmission electron microphotograph of a fine precipitate (Mo-based precipitate) effective for super-refining γ grains;

FIG. 3 is a graph showing a relation between an average grain size of prior austenite and a torsional fatigue strength with respect to Mo-added steel and Mo-free steel;

FIG. 4 is a graph showing a relation between an average grain size of prior austenite and a torsional fatigue strength with or without tampering;

FIG. 5 is a partial section view of a constant velocity joint; and

FIG. 6 is a section view showing a hardened texture layer in an inner wheel of a constant velocity joint.

DETD BEST MODE FOR CARRYING OUT THE INVENTION

The invention will be explained in detail below.

The components for machine structure according to the invention are a drive shaft for an automobile, an input shaft, an output shaft, a crankshaft, inner and outer wheels of a constant velocity joint, a hub, a gear and so on and have various forms and structures every the component. In any case, they have particularly a hardened layer subjected to a hardening in its portion requiring fatigue strengths or a whole thereof, and the hardened layer is important to have a hardness Hv of not less than 750 and an average grain size of prior austenite of not more than 7 μm over a full thickness of the hardened layer.

The findings arriving at the above knowledge will be described below.

[Grain Size of Prior Austenite in Hardened Layer]

When the average grain size of the prior austenite in the hardened layer through the induction hardening exceeds 7 μm, even if the hardness Hv of the hardened layer is increased to not less than 750 to improve the transgranular strength as mentioned later, the fatigue fracture is caused at a grain boundary of the prior austenite as a starting point. Therefore, grain size of the prior austenite in the hardened layer is required to be not more than 7 μm, preferably not more than 6 μm, more preferably not more than 5 μm, further preferably not more than 3 μm. Because, the intergranular strength becomes considerably strong

as the grain size is refined. In the conventional technique, even if the transgranular strength is increased, the intergranular strength is not increased and becomes a rate-determining step and hence it is not expected to further increase the strength. On the contrary, the intergranular strength is considerably increased by refining the grain size, so that it is expected to further increase the strength.

Now, the average grain size of the prior austenite in the induction hardened portion is measured as follows.

An outermost surface layer in the hardened layer after the induction hardening has a martensite structure of 100% as an area ratio. The region of 100% martensite structure continues to a certain thickness ranging from the surface of the hardened layer, but the surface area of the martensite structure violently decreases after that. In the invention, a region ranging from the surface of the induction hardened portion to a place that the surface area of the martensite structure decreases to 98% is the hardened layer, and an average depth from the surface is a thickness of the hardened layer.

As to the hardened layer, the average grain size of the prior austenite are measured at positions of 1/5, 1/2 and 4/5 of the whole of the thickness from the surface, and when the average grain size of the prior austenite is 7 μm in any positions, it is defined that the average grain size of the prior austenite grains is not more than 7 μm over the full thickness.

Moreover, the average grain size of the prior austenite grains is measured by corroding a section of the hardened layer with a corroding solution, which is formed by dissolving 50 g of picric acid in 500 g of water and adding 11 g of sodium dodecylbenzene sulfonate, 1 g of ferrous chloride and 1.5 g of oxalic acid, and observing the corroded section at 5 places every each position by means of an optical microscope of from 400 magnification (area of one place: 0.25 mm+0.225 mm) to 1000 magnification (area of one place: 0.10 mm+0.09 mm), and then analyzing with an image analysis equipment.

Incidentally, when the fatigue such as the rolling fatigue is dependent upon only the microstructure in the vicinity of an extremely surface layer, some effect is obtained even when the thickness of the hardened layer is about 1 mm, while in case of the torsional fatigue strength, it is preferable to make the thickness of the hardened layer to not less than 2 mm. It is more preferably not less than 2.5 mm, further preferably not less than 3 mm.

[Vickers Hardness of Hardened Layer]

When the Vickers hardness Hv of the hardened layer is less than 750, the transgranular strength of the hardened layer is weak, so that even if the prior austenite grains are refined, it can not be expected to improve the fatigue strength so as to match with such a refining. That is, even when the austenite grains are refined to increase the intergranular strength as mentioned above, if the transgranular strength is not increased, the transgranular fracture becomes rate-determined step and it can not be expected to increase the static strength and fatigue strengths. In the invention, therefore, the Vickers hardness Hv of the hardened layer (corresponding to the transgranular strength) is required to be not less than 750. Moreover, the upper limit of the Vickers hardness Hv of the hardened layer is not particularly limited, but it is preferable to be not more than 900 because when it exceeds 900, the amount of the elements added becomes large and hence the machinability of the base metal, the cold forgeability and the

resistance to quenching crack lower.

In the invention, the Vickers hardness is an average of values measured when 98 N (10 kgf) is struck to a position of 1/5 from the surface in the thickness of the hardened layer 5 times.

[Chemical Composition]

There will be described a chemical composition suitable for more increasing the transgranular strength of the hardened layer having the aforementioned particle size of prior austenite and Vickers hardness below.

  C: 0.3-1.5 mass %

  C is an element affecting a greatest influence on the induction hardenability, and contributes to the improvement of the fatigue strengths by increasing the transgranular strength of the hardened layer and more thickening the induction hardened portion. However, when the amount is less than 0.3 mass %, the hardened layer should be considerably increased for ensuring the required torsional fatigue strength, and hence the occurrence of quenching crack becomes remarkable and it is difficult to obtain a bainite structure as mentioned later. While, when it exceeds 1.5 mass %, it becomes inconvenient to ensure the machinability, cold forgeability and resistance to quenching crack. Therefore, the C amount is preferable to be 0.3-1.5 mass %.

  Si: 0.05-3.0 mass %

  Si increases the transgranular strength of the hardened layer and contributes to the improvement of the fatigue strengths. Further, it is an element useful for obtaining the bainite structure as mentioned later. From this meaning, it is preferable to be not less than 0.05 mass %. However, when it exceeds 3 mass %, it is difficult to ensure the machinability and cold forgeability because ferrite is solid-solution hardened, so that it is preferable to be not more than 3 mass %.

  Mn: 0.2-2.0 mass %

  Mn is an element for improving the induction hardenability and ensuring the thickness of the hardened layer. However, when the amount is less than 0.2 mass %, the effect is poor. Therefore, the Mn amount is preferable to be not less than 0.2 mass %, further preferably not less than 0.3 mass %. While, when it exceeds 2.0 mass %, the residual austenite increases after the hardening, which is easy to bring about the lowering of the hardness of the surface layer portion. Therefore, it is preferable to be not more than 2.0 mass %. Moreover, when the Mn amount is too large, the machinability tends to become disadvantageous, so that it is more preferably not more than 1.2 mass %, further preferably not more than 1.0 mass %.

  Al: 0.005-0.25 mass %

  Al is an element effective for the deoxidation of steel. Also, it is an element for suppressing the growth of austenite grains in the heating for the induction hardening to refine the induction hardened portion. When it exceeds 0.25 mass %, the effect is saturated and the increase of the cost is rather caused. Therefore, the Al amount is preferable to be not more than 0.25 mass %. Moreover, the above effect of Al is not developed when the

amount is less than 0.001 mass %, so that the amount is more preferably not less than 0.001 mass %. Further, it is preferable to be not less than 0.005 mass %.

Ti: 0.005-0.1 mass %

Ti has an effect that it bonds to N included as an inevitable impurity to form BN with B mentioned later to thereby prevent the fadeaway of the induction hardenability. Therefore, the amount is preferable to be not less than 0.005 mass %. While, when it exceeds 0.1 mass %, a great amount of TiN is formed and tends to lower the fatigue strengths as a starting point of fatigue fracture, so that the Ti amount is preferable to be 0.005-0.1 mass %. Further preferably, it is 0.01-0.07 mass %. Moreover, in order to effectively develop the hardenability of B by surely precipitating solid-soluted N as TiN, it is preferable that the Ti and N amounts are controlled to be Ti (mass %)/N (mass %)≥3.42.

  Mo: 0.05-0.6 mass %

  Mo has an action that austenite is refined by promoting the formation of bainite structure after the hot working in the heating for the induction hardening to refine the hardened layer. Also, it has an action that the growth of austenite grains in the heating for the induction hardening is suppressed to refine the hardened layer. Particularly, when the heating temperature in the induction hardening is 800-1000° C., preferably 800-950° C., the growth of austenite grains can be suppressed remarkably. Further, it is an element effective for the improvement of the hardenability , so that it is also used for the adjustment of the hardenability. In addition, it has an action of suppressing the formation of a carbide to prevent the lowering of the intergranular strength.

Thus, Mo is a very useful element for obtaining the effects of the invention, but when the amount is not less than 0.05 mass %, it is easy to render the average grain size of prior austenite in the hardened layer into not more than 7 μm, so that it is preferable to be not less than 0.05 mass %. While, when the Mo amount exceeds 0.6 mass %, the hardness of the steel material in the hot working for shaping into a component form considerably increases to lower the workability. Therefore, the Mo amount is preferably 0.05-0.6 mass %, more preferably 0.1-0.6 mass %, further preferably 0.3-0.4 mass %.

Moreover, according to the inventors' examinations, the dragging effect through solid-solution atoms (Solute Drug Effect), pinning effect and the like are considered as a possibility on the refining effect of the prior austenite grains through Mo. Although it is not necessarily clear how to take these effects or the other effect, it is confirmed to develop at least the pinning effect. The details will be described later.

B: 0.0003-0.006 mass %

B is useful for refining the grain size of the prior austenite in the hardened layer when the microstructure prior to the induction hardening includes the bainite structure or martensite structure as mentioned later. Also, the addition of a slight amount improves the induction hardenability and thickens the hardened layer and hence has an effect of improving the fatigue strengths. Furthermore, it is preferentially segregated in the grain boundary to reduce P

concentration segregated in the grain boundary, and hence the intergranular strength is increased to improve the fatigue strengths. However, the effects are poor when the amount is less than 0.0003 mass %. While, when it exceeds 0.006 mass %, the effects are saturated and the increase of the cost is rather caused. Therefore, the B amount is preferably 0.0003-0.006 mass %, more preferably 0.0005-0.004 mass %, further preferably 0.0015-0.003 mass %.

  S: not more than 0.1 mass %

  S is an element forming MnS to improve the machinability of steel. When the amount exceeds 0.1 mass %, it is segregated in the grain boundary to lower the intergranular strength. Therefore, the S amount is preferably not more than 0.1 mass %, further preferably not more than 0.06 mass %.

  P: not more than 0.10 mass %

  P increases the transgranular strength of the hardened layer and contributes to the improvement of the fatigue strengths. However, when the amount exceeds 0.10 mass %, it is segregated in the grain boundary to lower the intergranular strength. Therefore, the P amount is preferable to be not more than 0.10 mass %.

The remainder other than the above elements may be Fe and inevitable impurities. However, it is particularly preferable to adjust the chemical composition so as to satisfy at least one of the following equations (1)-(3):

  C>0.7 mass %   (1)

  Si>1.1 mass %   (2)

  P>0.02 mass %   (3)

By satisfying either of the equations (1) to (3) can be made the Vickers hardness Hv of the hardened layer to not less than 750 to increase the transgranular strength, whereby the effect of improving the fatigue strengths accompanied with the refining of the average particle size of prior austenite to not more than 7 μm can be developed considerably.

In the invention, the tempering treatment usually conducted after the induction hardening can be omitted. In this case, the temper softening is not caused, so that even if either of the equations (1) to (3) is not satisfied, Hv of not less than 750 can be satisfied in the above chemical composition range. In case of omitting the tempering, therefore, it is not necessarily required to satisfy at least one of the equations (1) to (3).

The inclusion of one or more selected from the following elements into the above chemical composition is effective to further improve the fatigue strengths.

  Cr: not more than 2.5 mass %

  Cr is effective for the improvement of the hardenability and is an element useful for ensuring the hardened depth, and may be added. However, when the amount is excessive, the carbide is stabilized to promote the formation of the residual carbide, which lowers the intergranular strength and deteriorates the fatigue strengths. Therefore, the Cr amount is desirable to be reduced as far as possible, but is allowed up to 2.5 mass %. Preferably, it is

not more than 1.5 mass %. Moreover, in order to develop the effect of improving the hardenability, it is preferable to be not less than 0.03 mass %.

Cu: not more than 1.0 mass %

Cu is effective for the improvement of the hardenability and also is solid-soluted in ferrite, in which the fatigue strengths are improved by such a solid solution strengthening. Furthermore, the formation of the carbide is suppressed to control the lowering of the intergranular strength due to the carbide and improve the fatigue strengths. However, when the amount exceeds 1.0 mass %, cracks are caused in the hot working, so that the addition amount is not more than 1.0 mass %. More preferably, it is not more than 0.5 mass %. Moreover, the addition amount of less than 0.03 mass % is small in the effect of improving the hardenability and the effect of suppressing the lowering of the intergranular strength, so that it is desirable to be not less than 0.03 mass %. Preferably, it is 0.1-1.0 mass %.

Ni: not more than 3.5 mass %

Ni is an element improving the hardenability and is used in case of adjusting the hardenability. Also, it is an element suppressing the formation of the carbide to suppress the lowering of the intergranular strength due to the carbide and improve the fatigue strengths. However, Ni is a very expensive element, so that when it is added over 3.5 mass %, the cost of steel material increases, and hence the addition amount is not more than 3.5 mass %. Moreover, the addition amount of less than 0.05 mass % is small in the effect of improving the hardenability and the effect of suppressing the lowering of the intergranular strength, so that it is desirable to be not less than 0.05 mass %. Preferably, it is 0.1-1.0 mass %.

Co: not more than 1.0 mass %

Co is an element suppressing the formation of the carbide to suppress the lowering of the intergranular strength due to the carbide and improve the fatigue strengths. However, Co is a very expensive element, so that when it is added over 1.0 mass %, the cost of steel material increases, and hence the addition amount is not more than 1.0 mass %. Moreover, the addition amount of less than 0.01 mass % is small in the effect of suppressing the lowering of the intergranular strength, so that it is desirable to be not less than 0.01 mass %. Preferably, it is 0.02-0.5 mass %.

Nb: not more than 0.1 mass %

Nb has an effect of improving the hardenability but also bonds to C, N in steel to act as a precipitation strengthening element. Also, it is an element improving the resistance to temper softening. The fatigue strengths are improved by these effects. However, when the amount exceeds 0.1 mass %, these effects are saturated, so that 0.1 mass % is an upper limit. Moreover, the addition amount of less than 0.005 mass % is small in the precipitation strengthening action and the effect of improving the resistance to temper softening, so that it is desirable to be not less than 0.005 mass %. Preferably, it is 0.01-0.05 mass %.

V: not more than 0.5 mass %

V bonds to C, N in steel to act as a precipitation strengthening element. Also, it is an element improving the resistance to temper softening. The fatigue strengths are improved by these effects. However, when the amount exceeds 0.5 mass %, the effects are saturated, so that it is not more than 0.5 mass %. Moreover, the addition amount of less than 0.01 mass % is small in the effect of improving the fatigue strengths, so that it is desirable to be not less than 0.01 mass %. Preferably, it is 0.03-0.3 mass %.

Ta: not more than 0.5 mass %

Ta may be added because there are an effect on the delay in the change of microstructure and an effect of preventing the deterioration of fatigue strengths, particularly rolling fatigue strength. However, when the amount is increased over 0.5 mass %, it does not contribute to the improvement of the strength, so that it is not more than 0.5 mass %. Moreover, in order to develop the action of improving the fatigue strengths, it is preferable to be not less than 0.02 mass %.

Hf: not more than 0.5 mass %

Hf may be added because there are an effect on the delay in the change of microstructure and an effect of preventing the deterioration of fatigue strengths, particularly rolling fatigue strength. However, when the amount is increased over 0.5 mass %, it does not contribute to the improvement of the strength, so that it is not more than 0.5 mass %. Moreover, in order to develop the action of improving the fatigue strengths, it is preferable to be not less than 0.02 mass %.

Sb: not more than 0.015 mass %

Sb may be added because there are an effect on the delay in the change of microstructure and an effect of preventing the deterioration of fatigue strengths, particularly rolling fatigue strength. However, when the amount is increased over 0.015 mass %, the toughness is deteriorated, so that it is not more than 0.015 mass %, preferably not more than 0.010 mass %. Moreover, in order to develop the action of improving the fatigue strengths, it is preferable to be not less than 0.005 mass %.

Further, in order to improve the machinability of steel, it is preferable to include the following elements.

W: not more than 1.0 mass %

W is an element of improving the machinability through embrittlement action. However, when it is added over 1.0 mass %, the effect is saturated and the cost disadvantageously increases, so that it is preferable to be not more than 1.0 mass %. Moreover, W is preferable to be not less than 0.005 mass % for the improvement of the machinability.

  Ca: not more than 0.005 mass %

  Ca forms a sulfide with MnS, which acts as a chip breaker to improve the machinability, so that it may be added, if necessary. However, when the amount is added over 0.005 mass %, the effect is saturated and the cost increases, so that it is not more than 0.005 mass %. Moreover, when it is less than 0.0001 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.0001 mass %.

Mg: not more than 0.005 mass %

Mg is a deoxidation element but also has an effect of improving the machinability as a stress concentration source, so that it may be added, if necessary. However, when the addition is excessive, the effect is saturated and the cost increases, so that it is not more than 0.005 mass %. Moreover, when it is less than 0.0001 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.0001 mass %.

Ta: not more than 0.1 mass %

  Se: not more than 0.1 mass %

  Se and Te form MnSe and MnTe through bonding with Mn, respectively, which act as a chip breaker to improve the machinability. However, when the amount exceeds 0.1 mass %, the effect is saturated and the cost increases, so that each amount is not more than 0.1 mass %. Also, in order to improve the machinability, it is preferable that Se amount is not less than 0.003 mass % and Te amount is not less than 0.003 mass %, respectively.

  Bi: not more than 0.5 mass %

  Bi improves the machinability through the fusion, lubrication and embrittlement actions in the cutting, and may be added for this purpose. However, when it is added over 0.5 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.5 mass %. Moreover, when it is less than 0.01 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.01 mass %.

Pb: not more than 0.5 mass %

Pb improves the machinability through the fusion, lubrication and embrittlement actions in the cutting, and may be added for this purpose. However, when it is added over 0.5 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.5 mass %. Moreover, when it is less than 0.01 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.01 mass %.

Zr: not more than 0.01 mass %

Zr forms a sulfide with MnS, which acts as a chip breaker to improve the machinability. However, when it exceeds 0.01 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.01 mass %. Moreover, when it is less than 0.0o3 mass %, the effect of improving the machinability is small, so that it is preferable to be not less than 0.003 mass %.

REM: not more than 0.1 mass %

REM forms a sulfide with MnS, which acts as a chip breaker to improve the machinability. However, when it exceeds 0.1 mass %, the effect is saturated but also the cost increases, so that it is not more than 0.1 mass %. Moreover, in order to improve the machinability, REM is preferable to be not less than 0.0001 mass %.

Although the above is described with respect to the preferable chemical composition range, the chemical composition is limited to the above range and further the steel texture prior to the induction hardening is made to the following texture, whereby there can be

obtained the aforementioned average particle size of the prior austenite of not more than 7 μm.

That is, it is preferable that the microstructure of the base metal, i.e. microstructure prior to the hardening (corresponding to the microstructure other than that of the hardened layer after the induction hardening) has a bainite structure and/or a martensite structure and a total of either or both of the bainite structure and the martensite structure is not less than 10 volume %. Because, the bainite structure or the martensite structure is a microstructure finely dispersing the carbide therein as compared with a ferrite-pearlite microstructure, so that an area of an ferrite/carbide interface as a nuclear formation site of austenite in the heating and hardening increases to refine the resulting austenite, which effectively contributes to the refining of the grain size in the hardened layer after the hardening. Further, such a refining of the grain size in the hardened layer after the hardening increases the intergranular strength and improves the fatigue strengths.

Here, it is more preferable that the total of either or both of the bainite structure and the martensite structure is not less than 20 volume %.

Also, it is preferable that an upper limit of a microstructure fraction in the total of either or both of the bainite structure and the martensite structure is about 90 volume %. Because, when the microstructure fraction exceeds 90 volume %, the effect of refining the prior austenite grains in the hardened layer through the hardening is saturated but also the machinability is rapidly deteriorated.

Moreover, as to the refining of the grain size in the hardened layer after the hardening, the martensite structure has an effect approximately equal to that of the bainite structure. However, the bainite structure is advantageous as compared with the martensite structure because the amount of alloying elements added is less from an industrial viewpoint, and the machinability is good, and it is possible to produce at a low cooling rate.

Further, the volume fraction ratio of bainite and martensite is preferable to be generally bainite:martensite=100:0-40:60. As the microstructure prior to the hardening, the martensite structure is preferable for refining the grain size of the prior austenite in martensite of the hardened layer after the induction hardening. However, since martensite is hard, if a great amount of martensite is included in the base metal, the machinability lowers. Therefore, the volume fraction ratio of bainite and martensite is preferable to be bainite:martensite=100:0-40:60.

Next, the production method of the component for machine structure according to the invention will be explained.

The component for machine structure according to the invention can be produced by subjecting a steel material having the aforementioned chemical composition to a hot working such as bar steel rolling, hot forging or the like to shape into a component and then subjecting at least a part of the component to an induction hardening under a condition of heating temperature: 800-1000° C. In this case, the term "at least a part" means a portion requiring fatigue strengths.

There is the following method for rendering the average grain size of prior austenite in the induction hardened portion into not more than 7 μm.

In the hot working, the total working ratio at 800-1000° C. is not less than 80% and the subsequent temperature region of 700-500° C. is cooled at a rate of not less than 0.2° C./s. Under these conditions, the microstructure prior to the hardening can be made to uniform and fine bainite and/or martensite structure (microstructure fraction: not less than 10 volume %). That is, since bainite and martensite are a microstructure finely dispersing the carbide therein as compared with a ferrite-pearlite microstructure, the area of ferrite/carbide interface as a nucleus formation site of austenite increases in the heating for the induction hardening, which is advantageous for refining the resulting austenite. For this end, it is required that the microstructure fraction in the total of either or both of bainite and martensite is not less than 10 volume %. Further, when the cooling rate in the temperature region of 700-500° C. is less than 0.2° C./s, the microstructure fraction in the total of either or both of bainite and martensite can not be made to not less than 10 volume %. More preferably, the cooling rate is not less than 0.5° C./s. Moreover, the volume ratio of bainite and martensite is preferable to be generally bainite:martensite=100:0-40:60 as previously mentioned.

Furthermore, the bainite and/or martensite structure prior to the induction hardening can be more refined by subjecting to a working of not less than 20% at a temperature region of lower than 800° C. Prior to the induction hardening (hereinafter referred to as a second working step), whereby the further refining of the prior austenite grains after the induction hardening can be attained, so that it is preferable to conduct the second working step. The working at the temperature region of lower than 800° C. may be carried out prior to the cooling at the above cooling rate (temperature region of 700-800° C.) in the hot working step, or a separate cold working may be conducted after the cooling or a warm working may be conducted by re-heating at a temperature of not higher than A.sub.1 transformation point. The working below 800° C. is preferable to be not less than 30%.

As the working method are mentioned, for example, cold forging, cold ironing, forming of rolling, shot peening and the like. By conducting the working below 800° C. is refined the bainite or martensite structure prior to the induction hardening, and hence the average grain size of the prior austenite in the hardened layer obtained after the induction hardening becomes finer to more improve the fatigue strengths.

The prior austenite grains having an average grain size of not more than 7 μm are first obtained by combining the adjustment of the microstructure prior to the hardening by the above working and cooling with the following induction hardening conditions.

At first, when the heating temperature is lower than 800° C., the formation of austenite microstructure is insufficient and the hardened layer can not be obtained. On the other hand, when the heating temperature exceeds 1000° C. or when the temperature rising rate at 600-800° C. is less than 300° C./s, the growth of the austenite grains is promoted and at the same time the scattering of the grains becomes large to lower the fatigue strengths. That is, as to the grain size of the prior austenite in the finally obtained hardened layer, it is important how to prevent the grain growth at the austenite zone in the heating for the hardening. When the microstructure prior to the

hardening is a microstructure having fine bainite or martensite as mentioned above, there are many nucleus formation sites for inverse transformation to austenite, so that when the cooling is started while the produced austenite grains do not grow, the average particle size of the prior austenite in the hardened microstructure can be refined. The growth of the austenite grains proceeds as the temperature becomes higher or as the keeping time in the austenite zone becomes longer, in order to prevent the grain growth and finally obtain the prior austenite grains having an average grain size of not more than 7 μm, the ultimate temperature in the heating is not higher than 1000° C. and the temperature rising rate at 600-800° C . is not less than 300° C./s.

Moreover, the ultimate temperature in the heating is preferable to be 800-950° C., and the temperature rising rate at 600-800° C. is preferably not less than 700° C/s, more preferably not less than 1000° C./s.

Also, as the residence time above 800° C. in the induction heating becomes long, the austenite grains grow and the grain size of the prior austenite tends to finally exceed over 7 μm, so that the residence time above 800° C. is preferable to be not more than 5 seconds. More preferably, the heating time is not more than 3 seconds.

Moreover, the above effects develop more remarkably in steels containing Mo within the range defined in the invention. That is, FIG. 1 shows results examined on a relation between a heating temperature in an induction hardening and a grain size of prior austenite in a hardened layer with respect to Mo-added steel and Mo-free steel.

The results shown in FIG. 1 are obtained as follows.

That is, 150 kg of a steel material having a chemical composition shown in the following a-steel, b-steel, c-steel, d-steel and e-steel is melted in a vacuum melting furnace, hot-forged into 150 mm square to form a dummy billet, which is subjected to a hot working of 80% at 850° C. and cooled at 0.7° C./ s within a temperature range of 700-500° C. to form a bar steel rolled material. Further, a part of the bar steels is subjected to a cold working of 20% after the cooling as a second working step.

(a-steel) C: 0.8 mass %, Si: 0.1 mass %, Mn: 0.78 mass %, P: 0.011 mass %, S: 0.019 mass %, Al: 0.024 mass %, Ti: 0.017 mass %, B: 0.0013 mass %, N: 0.0043 mass %, O: 0.0015 mass %, remainder: Fe and inevitable impurity

(b-steel) C: 0.53 mass %, Si: 0.1 mass %, Mn: 0.74 mass %, P: 0.011 mass %, S: 0.019 mass %, Al: 0.024 mass %, N: 0.0039 mass %, Mo: 0.37 mass %, Ti: 0.018 mass %, B: 0.0013 mass %, remainder: Fe and inevitable impurity

(c-steel) C: 0.9 mass %, Si: 0.1 mass %, Mn: 0.78 mass %, P: 0.011 mass %, S : 0.019 mass %, Al: 0.024 mass %, Mo: 0.37 mass %, Ti: 0.017 mass %, B: 0.0013 mass %, N: 0.0043 mass %,

remainder: Fe and inevitable impurity

(d-steel) C: 0.42 mass %, Si: 1.5 mass %,
Mn: 0.78 mass %, P: 0.011 mass %, S: 0.019
mass %, Al: 0.024 mass %, Mo: 0.37 mass %, Ti: 0.017
mass %, B: 0.0013 mass %, N: 0.0043 mass %, remainder:
Fe and inevitable impurity

(e-steel) C: 0.42 mass %, Si: 0.2 mass %,
Mn: 0.78 mass %, P: 0.05 mass %, S: 0.019
mass %, Al: 0.024 mass %, Mo: 0.37 mass %, Ti: 0.017
mass %, B: 0.0013 mass %, N: 0.0043 mass %, remainder:
Fe and inevitable impurity

A test specimen for torsional fatigue is sampled from the resulting bar
steel, subjected to an induction hardening at a frequency of
10-200 kHz and a heating temperature of 870-1050° C.
and further subjected to a tempering in a heating furnace under
conditions of 170° C.+30 minutes to obtain a test
material. The induction hardening conditions are adjusted so that the
temperature rising rate is not less than 300° C./
s and the residence time above 800° C. is not
more than 1 second.

The thus obtained test material is subjected to a torsional fatigue test
to measure a stress broken at torsion number of 10.sup.5 on the
torsional stepped test specimen of 18 mmφ. Also, the average grain
size of prior austenite in the hardened layer through the induction
hardening is measured by the previously mentioned method. Further, the
Vickers hardness is measured at a position of 1/5 of the full thickness
from the surface of the hardened layer. As the Vickers hardness is
adopted an average value measured when 98 N (10 kgf) is struck
5 times.

As shown in FIG. 1, in any of the Mo-added steels
and Mo-free steels, the grain size of prior
austenite in the hardened layer can be made small by lowering the
heating temperature in the induction hardening. Particularly, in case of
the Mo-added steels, the refining of the grain size
in the hardened layer is remarkably attained by rendering the ultimate
temperature in the heating to not higher than 1000° C.,
preferably not higher than 950° C.

Although the reason on this phenomenon is not clear, the following can
be presumed in relation to a carbonitride containing Mo and
Ti. That is, it is considered that in case of the Mo-added
steel, the above Mo-based fine carbonitride is
precipitated to develop a strong pinning force, whereby the austenite
grains are more refined as compared with the Mo-free
steel. However, even in the induction hardening for a short
time, it is considered that if the heating temperature largely exceeds
over 1000° C., the fine (Mo, Ti).sub.2(
C, N) is dissolved to lessen the pinning effect.

Moreover, it can be seen from FIG. 1 that in case of the Mo
-added steel, the grain size of the prior austenite can be
more refined by adding the second working step (cold working).

Further, the inventors have guessed that in the steels
containing Mo, the reason why the average grain size of prior
austenite in the hardened layer through the induction hardening can be
more refined to improve the fatigue strengths is due to the fact that

the fine Mo-based precipitates are highly dispersed to make
the above pinning effect large.

Now, the above a-steel is melted, rolled, subjected to
forgings of 80% at 850° C. and 25% at 750°
C. and then cooled in air (cooling rate in air: 0.8°
C./s). Then, a sample for the observation with a
transmission electron microscope is taken out from the starting material
prior to the induction hardening to observe a state of fine
precipitates. The sample for the observation with the transmission
electron microscope is proved by taking out a flat plate sample from the
central portion of the starting material and subjecting to an
electrolytic polishing with a perchloric acid-methanol based electrolyte
for thinning. As the observation zone is too thin, the frequency of
dropping out the precipitated particles becomes high, while as the zone
becomes too thick, it is difficult to recognize the precipitated
particles, so that the thickness of the observation zone is adjusted to
a range of 50-100 nm. Moreover, the thickness of the sample is estimated
from an electron energy loss spectrum.

In FIG. 2 is shown an example of the actually obtained transmission
electron microphotograph. Considering that the thickness of the sample
in the view field is about 0.1 µm, it is revealed that fine
precipitates having a diameter of about 5-10 nm are dispersed in a high
density of about 3000 particles per 1 µm.sup.3.

In the induction hardening, a nucleus of austenite is formed from a
grain boundary of bainite or martensite, a packet boundary, a carbide
and the like, which grows into grains. The above fine precipitates
control the movement of the grain boundary face so as to push a finger
(precipitates) into a balloon (grain boundary face) when the austenite
grain boundary face arrives at the precipitates and passes therethrough.
Such a control of moving the boundary face is called as a pinning. The
pinning force is large as the precipitates becomes small when the amount
of the precipitates is constant, or is strong as the amount of the
precipitates becomes large when the size of the precipitates is
constant.

In the induction heating according to the invention, it is guessed that
the pinning is caused by the fine precipitates as shown in FIG. 2 to
more promote the refining of the average grain size of prior austenite.
Furthermore, it is confirmed that the fine precipitates shown in FIG. 2
are existent even in the material after the induction hardening below
1000° C., from which it is considered that the hardly
solubility to the heat treatment at a high temperature for a short time
effectively acts to the control of the grain growth of austenite in the
induction hardening.

Then, the inventors conducted a model calculation by varying a
precipitation volume ratio of Mo in order to estimate the
influence of the precipitate dispersed state on the average grain size
of prior austenite in the induction heating treatment. That is, assuming
that the solid solution of Mo into the other precipitation
phase is slight, if a precipitation volume ratio: f and average grain
size: d of the Mo-based fine precipitates are determined,
there is estimated the number of the Mo-based fine precipitates
per 1 µm.sup.3 (precipitation density) in the case of uniform
dispersion precipitation. If the average grain size of the prior
austenite is governed by the pinning of the fine precipitation, such a
size is inversely proportional to the precipitation density. So, there
are examined the grain size and precipitation density developing the
pinning effect considering that the grain size and density of the

precipitates in FIG. 2 attain the average grain size of prior austenite of 2 μm. As a result, it has been found that the number of the precipitates per 1 μm.sup.3, which is directly effective for the control of the average grain size of the prior austenite, varies in accordance with the volume ratio of the precipitates, but when the volume ratio is, for example, about 0.2-0.4%, the sufficient pinning effect is developed and the preferable range capable of realizing the refining of the prior austenite grains is as follows.

That is, in order to attain the more refining of the prior austenite grains, it is preferable to ensure not less than 500 fine precipitated particles having a diameter of not more than 20 nm. Further, it is desirable to ensure not less than 1000 fine precipitates particles having a diameter of not more than 15 nm, more preferably not less than 2000 fine precipitated particles having a diameter of not more than 12 nm.

Then, as the residue after the precipitates are extracted from the base metal is identified by an X-ray diffractometry, it is guessed to be mainly hcp-type (Mo, Ti).sub.2(C, N).
Further, it has been revealed from results of EDX analysis attached with the transmission electron microscope that the atomic ratio of Mo to Ti is about 8:2 and Mo is a main component. Moreover, the precipitates include a composition deviated from a stoichiometric composition of complete (Mo, Ti).sub.2(C, N). In any case, it is considered to be a composite carbonitride including Mo and Ti.

Now, the (Mo, Ti).sub.2(C, N) precipitate is known to be relatively hard different from the precipitate of Cu or the like and considered to be high in the ability preventing the pass through the grain boundary face. Also, considering that Mo is fairly larger than Ti in the composition ratio and Mo is a hardly dispersing element, it is not thought that (Mo, Ti).sub.2(C, N) becomes rapidly large even it is kept within a temperature range of about 600-700° C. as a (Mo, Ti).sub.2(C, N) precipitation temperature for a short time. Therefore, in order to increase the precipitation amount of (Mo, Ti).sub.2(C , N) to enhance the distribution density, the newly precipitation of (Mo, Ti).sub.2(C, N) can be expected by isothermally keeping the above temperature range within a range of providing a microstructure fraction of bainite and martensite as mentioned later for a short tim while suppressing the coarsening of the previously precipitated (Mo, Ti).sub.2(C, N) at minimum.

In FIG. 3 is shown a relation between a grain size of prior austenite and a torsional fatigue strength in the hardened layer. As seen from this figure, in the Mo-added steel, the grain size becomes small even in a region that the grain size of the prior austenite is not more than 7 μm and also the fatigue properties are improved. On the contrary, in the Mo-free steel, as the grain size becomes not more than 7 μm, even if the grain size is made further smaller than the above value, the fatigue strengths are not improved. This is considered due to the fact that since the hardness of the hardened layer in the Mo-free steel is lower than that of the Mo-added steel, when the grain size of the prior austenite is refined over a certain level, the fatigue fracture is a transgranular fracture and is not affected by the grain size of the prior austenite.

Furthermore, it has been seen that when any content of Si, P is increased in the Mo-added steel c-steel, d-steel, e-steel), the effect of improving the torsional fatigue strength is large at a region that the grain size of the prior austenite is not more than 7 μm. Therefore, as the Vickers hardness of the hardened layer is examined, it has been proved that the effect of improving the torsional fatigue strengths by the refining of the prior austenite grains becomes very large when Hv of a-steel is 700, Hv of b-steel is 740, Hv of c-steel is 902, Hv of d-steel is 775, Hv of e-steel is 760 and the hardness Hv of the hardened layer is not less than 750.

Then, the inventors have discovered that an increment of the fatigue strengths by the refining of the grain size of the prior austenite can be made large by increasing the hardness of the above hardened layer and get an idea that the transgranular strength can be raised by omitting the tempering treatment after the induction hardening instead of the feature that the transgranular strength is raised by increasing any content of C, Si and P, and hence the fatigue strengths are raised by the omission of the tempering treatment.

Now, the torsional fatigue strength is examined on the above a-steel and b-steel provided that the tempering treatment is omitted in the step of preparing the specimen for the torsional fatigue test. The Vickers hardness Hv in the a-steel and b-steel omitting the tempering is 740 and 780, respectively.

In FIG. 4 is shown a relation between a grain size of prior austenite and torsional fatigue property in the hardened layer for the comparison between tempering and no tempering. From FIG. 4, it is seen that the fatigue strengths can be improved even by omitting the tempering.

Thus, the invention can positively adopt the method of conducting no tempering. In the usual high-strength steels, there is a case that cracks are caused in the component as the tempering is omitted. For this end, the tempering treatment after the induction hardening is a usual step. Such cracking is usually an intergranular fracture, which results from the lacking of the intergranular strength. In the invention, however, since the intergranular strength is high through the refining of the prior austenite grains, the cracking is hardly caused even in the omission of the tempering treatment. The omission of the tempering treatment is effective in the deterrence of softening due to the tempering and the reduction of the cost based on the tempering.

EXAMPLE 1

100 kg of a steel shown in Table 1 is melted and heated to 1200° C. and shaped into a sample for torsional fatigue test under hot working conditions and cold working conditions shown in Table 2. The shaped sample is first subjected to an induction hardening at 1050° C. and subsequently to an induction hardening under conditions shown in Table 2. Moreover, the induction hardening at 1050° C. is not carried out in Test No. 10. Also, in the tests other than Test Nos. 29 and 30, the tempering of 160° C.+1 h. is carried out after the induction hardening. The grain size of prior austenite and hardness in the induction hardened portion are measured in the same method as mentioned above. In the torsional fatigue test, stress broken at torsion number of 10.sup.5 is measured on the torsional stepped test specimen of 18 mmφ. Also, the microstructure prior to the induction hardening is observed by means of

an optical microscope to identify the microstructure, and at the same time the microstructure fraction (volume %) in one or total of bainite and martensite is measured.

The above measured results are also shown in Table 2. Nos. 7 and 25 are comparative examples wherein all contents of C, Si and P are low, and it is seen that the fatigue strengths in the invention examples are further improved as compared with these comparative examples. Also, when the content of Mo, B or Ti is insufficient as shown in Nos. 26, 27 and 28, the grain size of the prior austenite becomes coarse and the torsional fatigue strength lowers. In Nos. 26, 27 and 28, the microstructure of the base metal is particularly rendered into ferrite-pearlite, so that the grain size of the prior austenite is coarsened and the fatigue strengths lower. Furthermore, when the tempering treatment after the induction hardening is not conducted as shown in Nos. 29 and 30, the fatigue strengths are further improved as compared with steels of Nos. 1 and 7. In steel of No. 31, the total working ratio at 800-1000° C. in the hot working is small, so that the grain size of the prior austenite becomes large and the fatigue strengths are low.

TABLE 1

```
Symbol of   Chemical composition (mass %)
  steel        C      Si     Mn
           P      S      Al
           B        N      others          Mo     Ti

A          0.75   0.51   0.77   0.01   0.023  0.024     0.45   0.021  0.0023
           0.0040
B          1.21   0.50   0.78   0.01   0.023  0.023     0.44   0.023  0.0021
           0.0042
  C          1.45   0.50   0.78   0.01   0.023  0.024     0.46   0.022
           0.0022  0.0044
D          0.42   1.11   0.78   0.01   0.023  0.023     0.45   0.023  0.0022
           0.0044
E          0.41   1.25   0.77   0.01   0.022  0.023     0.45   0.023  0.0023
           0.0044
F          0.42   1.49   0.78   0.01   0.023  0.024     0.46   0.022  0.0021
           0.0042
G          0.48   0.50   0.78   0.02   0.023  0.023     0.44   0.021  0.0021
           0.0044
H          0.42   0.50   0.78   0.06   0.022  0.024     0.46   0.023  0.0022
           0.0040
I          0.41   0.50   0.77   0.10   0.022  0.023     0.45   0.023  0.0022
           0.0044
J          0.75   0.51   0.77   0.06   0.023  0.024     0.45   0.021  0.0023
           0.0040
K          0.41   1.25   0.77   0.06   0.022  0.023     0.45   0.023  0.0023
           0.0044
L          0.70   1.13   0.78   0.02   0.023  0.023     0.44   0.023  0.0021
           0.0042
M          0.70   0.50   0.78   0.01   0.023  0.023     0.44   0.023  0.0021
           0.0042   Cu: 0.3, Ni: 0.44
  N          0.70   0.50   0.78   0.01   0.023  0.023     0.44   0.023
           0.0021  0.0042   Co: 0.22, Nb: 0.040, V:
O          0.70   0.50   0.78   0.01   0.023  0.023     0.44   0.023  0.0021
           0.0042   Cr: 0.8
  P          0.70   0.50   0.78   0.01   0.023  0.023     0.44   0.023
           0.0021  0.0042   V: 0.3
Q          0.70   0.50   0.78   0.01   0.023  0.023     0.44   0.023  0.0021
```

	0.0042	Zr: 0.05							
R	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	Pb: 0.02							
S	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	
	0.0021	0.0042	Bi: 0.07						
T	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	Se: 0.01							
U	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	Te: 0.01							
V	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	Ca: 0.003							
W	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	REM: 0.002							
X	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021
	0.0042	Cu: 0.3, Ni: 0.44, Te: 0.01							
Y	0.48	0.51	0.79	0.011	0.022	0.025	0.45	0.021	0.0024
	0.0041								
Z	0.70	0.50	0.78	0.01	0.023	0.023	0.03	0.023	0.0021
	0.0042								
AA	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0002
	0.0042								
AB	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.002	0.0021
	0.0042								
AC	0.46	1.12	0.78	0.01	0.023	0.002	0.41	0.050	0.0022
	0.0044	Ca: 0.003							
AD	1.21	0.60	0.78	0.01	0.050	0.002	0.41	0.050	0.0022
	0.0044	Ca: 0.003							
AE	1.21	0.60	0.78	0.01	0.035	<0.001	0.41	0.050	0.0022
	0.0044	Ca: 0.003							

TABLE 2

Test No.	Symbol of steel	Hot working conditions Total working conditions ratio Residence time above 800° C. rising rate (%)		Microstructure of non-hardened portion Cooling rate of 500–700° C. Temperature (° C./s) (° C.)		Cold working condition above ratio (%)	Fraction of bainite + martensite construction (%)	Induction hardening Temperature Microstructure	Highest Heating
1	A	80	1.0		40	90	500 pearlite + bainite	890
2	B	80	1.0		40	90	500 Proeutectoid carbide + bainite + pearlite	880
3	C	80	1.0		30	90	500 Proeutectoid carbide + bainite + pearlite	880
4	D	80	1.0		20		500	880

							Microstructure	
	1						bainite + ferrite + pearlite	80
5	E	80	1.0	5	500	885	bainite + ferrite + pearlite	80
	1							
6	F	80	1.0	5	500	890	bainite + ferrite + pearlite	80
	1							
7	G	80	1.0	15	500	875	bainite + ferrite + pearlite	80
	1							
8	H	80	1.0	15	500	875	bainite + ferrite + pearlite	80
	1							
9	I	80	1.0	25	500	890	bainite + ferrite + pearlite	80
	1							
10	J	80	1.0	5	500	875	pearlite + bainite	90
	1							
11	K	80	1.0	5	500	865	bainite + ferrite + pearlite	80
	1							
12	L	80	1.0	25	500	875	pearlite + bainite	90
	1							
13	M	80	1.0	5	500	880	pearlite + bainite	90
	1							
14	N	80	1.0	10	500	875	pearlite + bainite	90
	2							
15	O	80	1.0	0	500	875	pearlite + bainite	90
	1							
16	P	80	1.0	40	500	880	pearlite + bainite	90
	1							
17	Q	80	1.0	25	500	865	pearlite + bainite	90
	1							
18	R	80	1.0	25	500	870	pearlite + bainite	90
	1							
19	S	80	1.0	15	500	880	pearlite + bainite	90
	1							
20	T	80	1.0	35	500	890	pearlite + bainite	90
	4							
21	U	80	1.0	40	500	885	pearlite + bainite	90
	1							
22	V	80	1.0	20	500	865	pearlite +	90
	1							

bainite

No.	Steel				Microstructure			
23	W 1	80	1.0	15	pearlite + bainite	90	500	875
24	X 1	80	1.0	0	pearlite + bainite	90	500	865
25	Y 1	80	1.0	35	pearlite + bainite	80	500	890
26	Z 1	80	1.0	20	ferrite + pearlite	0	500	880
27	AA 1	80	1.0	35	ferrite + pearlite	0	500	890
28	AB 1	80	1.0	20	ferrite + pearlite	0	500	880
29	A 1	80	1.0	20	pearlite + bainite	90	500	880
30	G 1	80	1.0	15	bainite + ferrite + pearlite	80	500	875
31	A 1	50	1.0	10	pearlite + bainite	90	500	890
32	AC 1	80	0.5	0	bainite + ferrite + pearlite	80	300	950
33	AD 1	80	0.5	0	Proeutectoid carbide + bainite + pearlite	80	300	950
34	AE 1	80	0.5	0	Proeutectoid carbide + bainite + pearlite	80	300	950

Microstructure of hardened portion

Average Grain Size of Prior γ (μm)

Vickers Hardness

Fatigue property

Torsional Fatigue Strength (+105) (MPa)

Remarks

Vickers Hardness γ (μm)	(MPa)	Remarks
3.4	941	Example
2.4	959	Invention Example
3.5	989	Invention Example

Test No.	(Hv)
1	823
2	901
3	917
4	751

1.8	890	Invention Example
1.8	892	Invention Example
2.6	900	Invention Example
2.2	800	Comparative Example
2.1	840	Invention Example
2.7	869	Invention Example
3.4	922	Invention Example
2.8	910	Invention Example
2.7	976	Invention Example
2.7	925	Invention Example
3.2	933	Invention Example
1.8	930	Invention Example
3.2	943	Invention Example
1.6	936	Invention Example
3.1	935	Invention Example
1.7	936	Invention Example
3.8	934	Invention Example
3.1	920	Invention Example
2.7	929	Invention Example
2.3	930	Invention Example
1.9	935	Invention Example
2.0	805	Comparative Example
9.7	701	Comparative Example
8.7	729	Comparative Example
8.5	741	Comparative Example
3.4	990	Invention Example
2.2	890	Invention Example
8.1	780	Comparative Example
5.0	930	Invention Example
5.3	890	Invention Example
5.2	930	Invention Example

5	767
6	772
7	695
8	750
9	763
10	833
11	783
12	764
13	768
14	764
15	764
16	767
17	761
18	759
19	754
20	754
21	756
22	752
23	750
24	770
25	694
26	690
27	673
28	694
29	820
30	752
31	823
32	760
33	900
34	905

EXAMPLE 2

As a component for machine structure according to the invention is prepared a constant velocity joint 12 interposed for transmitting a motive energy from a drive shaft 10 to a wheel hub 11 as shown in FIG. 5.

The constant velocity joint 12 is a combination of an outer wheel 13 sand an inner wheel 14. That is, the inner wheel 14 is swingably fixed to an inside of a mouth portion 13a of the outer wheel 13 through balls 15 fitted into a ball track groove formed in the inner face of the mouth portion 13a, while the drive shaft 10 is connected to the inner wheel 14. A stem portion 13b of the outer wheel 13 is, for example, spline-bonded to the hub 11, whereby the motive energy is transmitted from the drive shaft 10 to the hub 11 of the wheel.

A starting material of steel having a chemical composition shown in Table 3 is melted in a converter and continuously cast to form a cast bloom. The cast bloom has a size of 300+400 mm. The cast bloom is rolled into a billet of 150 mm square through a break down step and then rolled into a bar steel of 55 mmϕ.

Then, the bar steel is cut into a given length and hot-forged to form an inner wheel of a constant velocity joint (outer diameter: 45 mm and inner diameter: 20 mm), and thereafter a groove for spline bond is formed on a fitting face thereof by machining or roll forming. Also, a rolling face for balls is formed by machining or cold forging. The cooling after the hot forging is carried out under conditions shown in Table 4. At this moment, the total working ratio in the hot forging and cold forging is obtained by adjusting an area reducing ratio of a section perpendicular to an axial direction of the rolling face.

As shown in FIG. 6, the rolling face 14a for balls lying to the outer wheel of the constant velocity joint is rendered into a hardened texture layer 16 by subjecting to an induction hardening at 1050° C. and to a subsequent induction hardening under conditions shown in Table 4 in an induction hardening apparatus with a frequency of 15 Hz, which is tempered under conditions of 180° C .+2 h in a heating furnace. Moreover, the tempering is omitted in a part of the constant velocity joints. The drive shaft is fitted onto the fitting face of the inner wheel of the thus obtained constant velocity joint, which is mounted to the mouth portion of the outer wheel of the constant velocity joint through balls (steel balls), while the hub is fitted into the stem portion of the outer wheel of the constant velocity joint, whereby there is obtained a constant velocity joint unit (see FIG. 5). Moreover, the specifications of the ball, outer wheel, drive shaft and hub are shown as follows.
Ball: hardened and tempered steel of high carbon
    chromium bearing steel SUJ2
Outer Wheel: induction hardened and tempered steel of carbon
    steel for machine structure
Hub: induction hardened and tempered steel of carbon
    steel for machine structure
Drive Shaft: induction hardened and tempered steel of carbon
    steel for machine structure

Then, the durable test for rolling fatigue strength in the rolling face for balls is carried out in a motive energy transmission system of the constant velocity joint in which a rotational motion of the drive shaft is transmitted to the inner wheel of the constant velocity joint and then through the inner wheel to the hub.

The test for the rolling fatigue strength is carried out by the motive energy transmission under conditions that a torque is 900 N.m and an operating angle (an angle defined between axial line of inner wheel and axial line of drive shaft) is 20° and a revolution number is 300 rpm, and a time causing the peeling in the rolling face of the inner wheel of the constant velocity joint is evaluated as the rolling fatigue strength. Moreover, the dimensions and forms of the drive shaft, outer wheel of constant velocity joint and the like are set so that the inner wheel of the constant velocity joint becomes weakest in the durable test.

Also, the average grain size of prior austenite and hardness in the hardened layer with respect to the inner wheel of the constant velocity joints prepared under the same conditions are measured by the same methods as mentioned above.

In Table 4 are also shown these results.

TABLE 3

Symbol of steel	C	Si	Mn	P	S	Al	Mo	Ti	B	N	others
A	0.75	0.49	0.75	0.01	0.023	0.023	0.45	0.022	0.0021	0.0041	
B	1.23	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0022	0.0042	
C	1.44	0.50	0.78	0.01	0.023	0.024	0.46	0.021		0.0021	0.0044
D	0.41	1.10	0.78	0.01	0.023	0.024	0.45	0.023	0.0022	0.0044	
E	0.42	1.30	0.77	0.01	0.022	0.023	0.45	0.022	0.0023	0.0044	
F	0.42	1.50	0.78	0.01	0.023	0.024	0.46	0.022	0.0021	0.0042	
G	0.48	0.49	0.78	0.02	0.023	0.023	0.44	0.023	0.0023	0.0044	
H	0.41	0.50	0.78	0.06	0.022	0.024	0.46	0.023	0.0022	0.0040	
I	0.42	0.50	0.77	0.10	0.022	0.023	0.45	0.023	0.0022	0.0044	
J	0.75	0.51	0.77	0.06	0.023	0.024	0.45	0.023	0.0021	0.0040	
K	0.41	1.27	0.77	0.06	0.022	0.024	0.45	0.023	0.0023	0.0044	
L	0.70	1.10	0.78	0.02	0.023	0.023	0.44	0.021	0.0021	0.0042	
M	0.70	0.50	0.77	0.01	0.023	0.023	0.44	0.023	0.0021	0.0040	Cu: 0.31, Ni: 0.46
N	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.021		0.0021	0.0042 — Co: 0.20, Nb: 0.043, V: 0.18
O	0.70	0.50	0.77	0.01	0.023	0.023	0.44	0.023	0.0022	0.0042	Cr: 0.8
P	0.70	0.50	0.78	0.01	0.023	0.024	0.44	0.023		0.0021	0.0042 — V: 0.3
Q	0.70	0.50	0.78	0.01	0.023	0.023	0.44	0.023	0.0021	0.0042	Zr: 0.05
R	0.70	0.50	0.79	0.01	0.023	0.023	0.44	0.023	0.0021		

Chemical composition (mass %)

```
       0.0042   Pb: 0.02
  S      0.70    0.50    0.78    0.01   0.023  0.023    0.44    0.023
       0.0022   0.0042  Bi: 0.07
  T      0.70    0.50    0.77    0.01   0.023  0.024    0.44    0.023  0.0021
       0.0042   Se: 0.01
  U      0.70    0.50    0.78    0.01   0.023  0.023    0.44    0.023  0.0021
       0.0040   Te: 0.01
  V      0.70    0.50    0.78    0.01   0.023  0.023    0.44    0.023  0.0021
       0.0042   Ca: 0.003
  W      0.70    0.50    0.79    0.01   0.023  0.024    0.44    0.023  0.0021
       0.0042   REM: 0.002
  X      0.70    0.50    0.78    0.01   0.023  0.023    0.44    0.023  0.0021
       0.0042   Cu: 0.3, Ni: 0.44,
              Te: 0.01
  Y      0.48    0.51    0.79    0.01   0.022  0.024    0.45    0.021  0.0024
       0.0041
  Z      0.70    0.50    0.78    0.01   0.023  0.023    0.02    0.022  0.0021
       0.0042
  AA     0.70    0.50    0.78    0.01   0.023  0.025    0.44    0.023  0.0002
       0.0042
  AB     0.70    0.50    0.78    0.01   0.023  0.023    0.44    0.002  0.0021
       0.0042
  AC     0.46    1.12    0.78    0.01   0.023  0.002    0.41    0.050  0.0022
       0.0044   Ca: 0.003
  AD     1.21    0.60    0.78    0.01   0.050  0.002    0.41    0.050  0.0022
       0.0044   Ca: 0.003
  AE     1.21    0.60    0.78    0.01   0.035  <0.001   0.41    0.050  0.0022
       0.0044   Ca: 0.003
```

TABLE 4

```
                        Hot working
             conditions
          Microstructure of
                        Total
          Microstructure of non-            hardened portion
                        working          Cold         Induction hardening
          conditions             hardened portion
          Average               Fatigue
                        ratio    Cooling      working                   Highest
          Residence             property                                Grain
                        above    rate of      condition  Temperature   Heating
          Time                                of bainite +              size of
          Presence or  Rolling
               Symbol  800° C.  500-700° C.
          Working      rising rate  Temperature  Above          Microstructure
          martensite   Vickers         prior γ absence of   Fatigue
Test No.  of steel  (%)    (° C./s) (° C./s)
          ratio (%)  (° C./s)
          800° C. (s) construction          (%)
          Hardness (Hv)  (μm) tempering          life (hr) Remarks

1          A         80      1.0          40          500          890
   1                 Pearlite +          90          823            3.4
   presence          163     Invention Example
                     bainite
2          B         80      1.0          40          500          880
   1                 Proeutectoid        90          901            2.4
   presence          177     Invention Example
                     carbide + bainite +
```

```
                              pearlite
3      C        80     1.0        30        500
       880      1          proeutectoid      90              917
       3.5   presence    173     Invention Example
                     carbide + bainite +
                              pearlite
4      D        80     1.0        20        500          885
       1        bainite +         80        751          1.8
       presence     151     Invention Example
                        ferrite +
                              pearlite
5      E        80     1.0        5         500          890
       1        bainite +         80        767          1.8
       presence     148        Invention Example
                        ferrite +
                              pearlite
6      F        80     1.0        5         500          875
       1        bainite +         80        772          2.6
       presence     155        Invention Example
                        ferrite +
                              pearlite
7      G        80     1.0        15        500          875
       1        bainite +         80        695          2.2
       presence     141        Comparative
                        ferrite +
       Example
                              pearlite
8      H        80     1.0        15        500          890
       1        bainite +         80        750          2.1
       presence     152        Invention Example
                        ferrite +
                              pearlite
9      1        80     1.0        25        500          875
       1        bainite +         80        763          2.7
       presence     152        Invention Example
                        ferrite +
                              pearlite
10     J        80     1.0        5         500          865
       1        pearlite +        90        833          3.4
       presence     167        Invention Example
                          bainite
11     K        80     1.0        5         500          875
       1        bainite +         80        783          2.8
       presence     150        Invention Example
                        ferrite +
                              pearlite
12     L        80     1.0        25        500          880
       1        Pearlite +        90        764          2.7
       presence     181        Invention Example
                          bainite
13     M        80     1.0        5         500          875
       1        Pearlite +        90        768          2.7
       presence     165        Invention Example
                          bainite
14     N        80     1.0        10        500
       875      2          pearlite +       90              764
       3.2   presence    164        Invention Example
                          bainite
15     O        80     1.0        0         500          880
       1        pearlite +        90        764          1.8
       presence     166        Invention Example
                          bainite
```

No.	Steel							Microstructure						Classification
16	P	80	1.0	40	500	865	1	pearlite + bainite	90	767	3.2	presence	172	Invention Example
17	Q	80	1.0	25	500	865	1	pearlite + bainite	90	761	1.6	presence	168	Invention Example
18	R	80	1.0	25	500	870	1	pearlite + bainite	90	759	3.1	presence	161	Invention Example
19	S	80	1.0	15	500	880	1	pearlite + bainite	90	754	1.7	presence	159	Invention Example
20	T	80	1.0	35	500	890	4	pearlite + bainite	90	754	3.8	presence	160	Invention Example
21	U	80	1.0	40	500	885	1	pearlite + bainite	90	756	3.1	presence	163	Invention Example
22	V	80	1.0	20	500	865	1	pearlite + bainite	90	752	2.7	presence	164	Invention Example
23	W	80	1.0	15	500	875	1	Pearlite + bainite	90	750	2.3	presence	162	Invention Example
24	X	80	1.0	0	500	865	1	pearlite + bainite	90	770	1.9	presence	160	Invention Example
25	Y	80	1.0	35	500	890	1	pearlite + bainite	80	694	2.0	presence	141	Comparative Example
26	Z	80	1.0	20	500	880	1	ferrite + pearlite	0	690	9.7	presence	120	Comparative Example
27	AA	80	1.0	35	500	890	1	Ferrite + pearlite	0	673	8.7	presence	131	Comparative Example
28	AB	80	1.0	20	500	880	1	ferrite + pearlite	0	694	8.5	presence	137	Comparative Example
29	A	80	1.0	20	500	880	1	pearlite + bainite	90	820	3.4	absence	180	Invention Example
30	G	80	1.0	15	500	875	1	Bainite + ferrite +	80	752	2.2			

```
      absence      150        Invention Example
                        pearlite
31       A       50       1.0            10         500        890
1                pearlite +              90         823          8.1
presence     140        Comparative
Example
             bainite
32       AC      70       0.7            0          300        950
1                bainite + ferrite +     80         760          5.0
presence     162        Invention Example
                        pearlite
33       AD      70       0.7            0          300        950
1                Proeutectoid            80         900          5.2
presence     179        Invention Example
                        carbide + bainite +
                        pearlite
34       AE      70       0.7            0          300        950
1                Proeutectoid            80         906          5.2
presence     173        Invention Example
                        carbide + bainite +
                        pearlite
```

As seen from Table 4, Nos. 7 and 25 are comparative examples wherein all contents of C, Si and P are low, and the rolling fatigue life is improved in the invention examples as compared with these comparative examples. Also, when the content of Mo, B or Ti is lacking as in Nos. 26, 27 and 28, the grain size of the prior austenite is coarsened and the rolling fatigue life lowers. Further, in Nos. 26, 27 and 28, the microstructure of the base material is particularly ferrite-pearlite, so that the grain size of the prior austenite is coarsened and the rolling fatigue life lowers. In addition, when the tempering treatment is omitted after the induction hardening as in Nos. 29 and 30, the rolling fatigue life is further improved as compared with No. 1 steel and No. 2 steel, respectively. Moreover, in No. 31 steel, the total working ration of 800-1000° C. in the hot working is small, so that the grain size of the prior austenite becomes large and the rolling fatigue life is low.

CLM   What is claimed is:

1. A component for machine structure characterized by comprising a hardened layer through an induction hardening in at least a part thereof, in which the hardened layer has a hardness Hv of not less than 750 and an average grain size of prior austenite grains is not more than 7 μm over a full thickness of the hardened layer.

2. A component for machine structure according to claim 1, which has a chemical composition comprising C: 0.3-1.5 mass %, Si : 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo:10 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3): C>0.7 mass %   (1)   Si>1.1 mass %   (2)   P>0.02 mass %   (3)

3. A component for machine structure according to claim 2, wherein a content of Al in the chemical composition is Al: 0.005-0.25 mass %.

4. A component for machine structure according to claim 2, wherein the chemical composition further contains one or more selected from

Cr: not more than 2.5 mass %, Cu: not more than 1.0
mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0
mass %, Nb: not more than 0.1 mass %, V: not more than 0.5
mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and
Sb: not more than 0.015 mass %.

5. A component for machine structure according to claim 2, wherein the
chemical composition further contains one or more selected from W: not
more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not
more than 0.005 mass %, Te: not more than 0.1 mass %,
Se: not more than 0.1 mass %, Bi: not more than 0.5
mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and
REM: not more than 0.1 mass %.

6. A component for machine structure according to claim 1, which has a
chemical composition comprising C: 0.3-1.5 mass %, Si
: 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more
than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %,
B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and
P: not more than 0.10 mass % and the remainder being Fe
and inevitable impurities in which the hardened layer is not subjected
to a tempering.

7. A component for machine structure according to claim 6, wherein a
content of Al in the composition is Al: 0.005-0.25
mass %.

8. A component for machine structure according to claim 6, wherein the
chemical composition further contains one or more selected from
Cr: not more than 2.5 mass %, Cu: not more than 1.0
mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0
mass %, Nb: not more than 0.1 mass %, V: not more than 0.5
mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and
Sb: not more than 0.015 mass %.

9. A component for machine structure according to claim 6, wherein the
chemical composition further contains one or more selected from W: not
more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not
more than 0.005 mass %, Te: not more than 0.1 mass %,
Se: not more than 0.1 mass %, Bi: not more than 0.5
mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and
REM: not more than 0.1 mass %.

10. A component for machine structure according to claim 2, wherein
Mo-based precipitate is dispersed in an amount of not less than
500 per 1 μm3 and an average particle size of the Mo-based
precipitate is not more than 20 nm.

11. A method of producing a component for machine structure by
subjecting at least a part of a starting material having a chemical
composition comprising C: 0.3-1.5 mass %, Si:
0.05-3.0. mass %, Mn: 0.2-2.0 mass %, Al: not more
than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %,
B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and
P: not more than 0.10 mass %, and the remainder being Fe
and inevitable impurities, and satisfying at least one of the following
equations (1)-(3): C>0.7 mass % (1) Si>1.1 mass %
(2) P>0.02 mass % (3) to an induction hardening at least
once, wherein either or both of bainite structure and martensite
structure in steel microstructure of the starting material
prior to the induction hardening is adjusted to not less than 10 volume
%, and an ultimate temperature of the induction hardening is not higher

than 1000° C.

12. A method of producing a component for machine structure according to claim 11, wherein a content of Al in the chemical composition is Al: 0.005-0.25 mass %.

13. A method of producing a component for machine structure according to claim 11, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

14. A method of producing a component for machine structure according to claim 11, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

15. A material for induction hardening used for the formation of a component for machine structure having in at least a part of its surface a hardened layer with an average grain size of prior austenite of not more than 7 pm through an induction hardening, characterized by having a chemical composition comprising C: 0.3-1.5 mass %, Si : 0.05-3.0 mass %, Mn: 0.2-2.0 mass %, Al: not more than 0.25 mass %, Ti: 0.005-0.1 mass %, Mo: 0.05-0.6 mass %, B: 0.0003-0.006 mass %, S: not more than 0.1 mass % and P: not more than 0.10 mass %, and the remainder being Fe and inevitable impurities, and satisfying at least one of the following equations (1)-(3): C>0.7 mass % (1) Si>1.1 mass % (2) P>0.02 mass % (3) and having a steel microstructure in which either or both of bainite structure and martensite structure is not less than 10 volume %.

16. A material for induction hardening according to claim 15, wherein a content of Al in the composition is Al: 0.005-0.25 mass %.

17. A material for induction hardening according to claim 15, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

18. A material for induction hardening according to claim 15, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

19. A material for induction hardening according to claim 15, wherein Mo-based precipitate is dispersed in an amount of not less than 500 per 1 μm.sup.3 and an average particle size of the Mo-based precipitate is not more than 20 nm.

20. A component for machine structure according to claim 3, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

21. A component for machine structure according to claim 20, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

22. A component for machine structure according to claim 3, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

23. A component for machine structure according to claim 4, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

24. A component for machine structure according to claim 7, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

25. A component for machine structure according to claim 24, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

26. A component for machine structure according to claim 7, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

27. A component for machine structure according to claim 8, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and

REM: not more than 0.1 mass %.

28. A method of producing a component for machine structure according to claim 12, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

29. A method of producing a component for machine structure according to claim 28, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

30. A method of producing a component for machine structure according to claim 12, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

31. A method of producing a component for machine structure according to claim 13, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

32. A material for induction hardening according to claim 16, wherein the chemical composition further contains one or more selected from Cr: not more than 2.5 mass %, Cu: not more than 1.0 mass %, Ni: not more than 3.5 mass %, Co: not more than 1.0 mass %, Nb: not more than 0.1 mass %, V: not more than 0.5 mass %, Ta: not more than 0.5 mass %, Hf: not more than 0.5 mass % and Sb: not more than 0.015 mass %.

33. A material for induction hardening according to claim 32, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

34. A material for induction hardening according to claim 16, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %, Se: not more than 0.1 mass %, Bi: not more than 0.5 mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and REM: not more than 0.1 mass %.

35. A material for induction hardening according to claim 17, wherein the chemical composition further contains one or more selected from W: not more than 1.0 mass %, Ca: not more than 0.005 mass %, Mg: not more than 0.005 mass %, Te: not more than 0.1 mass %,

Se: not more than 0.1 mass %, Bi: not more than 0.5
mass %, Pb: not more than 0.5 mass %, Zr: not more than 0.01 mass % and
REM: not more than 0.1 mass %.

36. A material for induction hardening according to claim 16, wherein
Mo-based precipitate is dispersed in an amount of not less than
500 per 1 μm3 and an average particle size of the Mo-based
precipitate is not more than 20 nm.

37. A material for induction hardening according to claim 17, wherein
Mo-based precipitate is dispersed in an amount of not less than
500 per 1 μm3 and an average particle size of the Mo-based
precipitate is not more than 20 nm.

38. A material for induction hardening according to claim 18, wherein
Mo-based precipitate is dispersed in an amount of not less than
500 per 1 μm3 and an average particle size of the Mo-based
precipitate is not more than 20 nm.

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INCL   INCLM: 420/084.000
       INCLS: 148/567.000; 420/121.000; 420/089.000
NCL    NCLS:  420/084.000
       NCLS:  148/567.000; 420/089.000; 420/121.000
IC     IPCI   C22C0038-00 [I,A]; C21D0001-42 [I,A]; C22C0038-20 [I,A]
CAS INDEXING IS AVAILABLE FOR THIS PATENT.


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L22  ANSWER 1 OF 30  USPATFULL on STN
PI     US 20080247900     A1  20081009

L22  ANSWER 2 OF 30  USPATFULL on STN
PI     US 20070193658     A1  20070823

L22  ANSWER 3 OF 30  USPATFULL on STN
PI     US 20070163687     A1  20070719

L22  ANSWER 4 OF 30  USPATFULL on STN
PI     US 7195736         B1  20070327
       WO 2001059170          20010816

L22  ANSWER 5 OF 30  USPATFULL on STN
PI     US 20070062619     A1  20070322

L22  ANSWER 6 OF 30  USPATFULL on STN
PI     US 20060285992     A1  20061221

L22  ANSWER 7 OF 30  USPATFULL on STN
PI     US 20060239853     A1  20061026

L22  ANSWER 8 OF 30  USPATFULL on STN
PI     US 20060157163     A1  20060720

L22  ANSWER 9 OF 30  USPATFULL on STN
PI     US 20050265886     A1  20051201

L22  ANSWER 10 OF 30  USPATFULL on STN
PI     US 20050252580     A1  20051117

L22  ANSWER 11 OF 30  USPATFULL on STN
PI     US 20050207687     A1  20050922
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L22  ANSWER 12 OF 30  USPATFULL on STN
PI    US 20050161125      A1  20050728


L22  ANSWER 13 OF 30  USPATFULL on STN
PI    US 20050058567      A1  20050317
      US 7445680          B2  20081104


L22  ANSWER 14 OF 30  USPATFULL on STN
PI    US 20050025658      A1  20050203


L22  ANSWER 15 OF 30  USPATFULL on STN
PI    US 20050022906      A1  20050203


L22  ANSWER 16 OF 30  USPATFULL on STN
PI    US 20040129243      A1  20040708
      US 7472674          B2  20090106


L22  ANSWER 17 OF 30  USPATFULL on STN
PI    US 20040055667      A1  20040325
      US 6911268          B2  20050628


L22  ANSWER 18 OF 30  USPATFULL on STN
PI    US 20030178105      A1  20030925
      US 6764645          B2  20040720


L22  ANSWER 19 OF 30  USPATFULL on STN
PI    US 20030152476      A1  20030814


L22  ANSWER 20 OF 30  USPATFULL on STN
PI    US 20030138343      A1  20030724
      US 6797231          B2  20040928


L22  ANSWER 21 OF 30  USPATFULL on STN
PI    US 20030113223      A1  20030619
      US 6783728          B2  20040831


L22  ANSWER 22 OF 30  USPATFULL on STN
PI    US 20030084965      A1  20030508
      US 6838048          B2  20050104



=> s l22 or l14
L23        69 L22 OR L14

=> duprem l23
DUPREM IS NOT A RECOGNIZED COMMAND
The previous command name entered was not recognized by the system.
For a list of commands available to you in the current file, enter
"HELP COMMANDS" at an arrow prompt (=>).

=> dup rem l23
PROCESSING COMPLETED FOR L23
L24        69 DUP REM L23 (0 DUPLICATES REMOVED)

=> d l24 1-69 pi

L24  ANSWER 1 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
      PATENT NO.      KIND  DATE      APPLICATION NO.      DATE
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PI    JP 2009001887    A     20090108  JP 2007-165962       20070625
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L24  ANSWER 2 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE        APPLICATION NO.          DATE
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PI   JP 2009001864      A     20090108    JP 2007-163851          20070621

L24  ANSWER 3 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE        APPLICATION NO.          DATE
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PI   JP 2008308727      A     20081225    JP 2007-157349          20070614

L24  ANSWER 4 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE        APPLICATION NO.          DATE
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PI   JP 2008308704      A     20081225    JP 2007-154899          20070612

L24  ANSWER 5 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE        APPLICATION NO.          DATE
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PI   JP 2008149340      A     20080703    JP 2006-338791          20061215

L24  ANSWER 6 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE        APPLICATION NO.          DATE
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PI   JP 2008013788      A     20080124    JP 2006-183512          20060703

L24  ANSWER 7 OF 69  USPATFULL on STN
PI   US 20080247900     A1   20081009

L24  ANSWER 8 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE        APPLICATION NO.          DATE
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PI   WO 2007007423      A1    20070118    WO 2005-JP22368         20051206
     W:   AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH,
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          GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ,
          LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ,
          NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG,
          SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
          YU, ZA, ZM, ZW
     RW:  AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE,
          IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR, BF, BJ,
          CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG, BW, GH,
          GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY,
          KG, KZ, MD, RU, TJ, TM
     JP 2007016278      A     20070125    JP 2005-198794          20050707
     JP 2007023351      A     20070719    JP 2005-208597          20050719
     JP 2007031755      A     20070208    JP 2005-214625          20050725
     CN 101218362       A     20080709    CN 2005-80050983        20080104
     KR 2008027913      A     20080328    KR 2008-702741          20080201
     IN 2008CN00647     A     20081128    IN 2008-CN647           20080207

L24  ANSWER 9 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.        KIND   DATE        APPLICATION NO.          DATE
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PI   JP 2007031787      A     20070208    JP 2005-217453          20050727

L24  ANSWER 10 OF 69  USPATFULL on STN
PI   US 20070193658     A1   20070823

L24  ANSWER 11 OF 69  USPATFULL on STN
PI   US 20070163687     A1   20070719
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L24  ANSWER 12 OF 69  USPATFULL on STN
PI    US 20070062619     A1  20070322

L24  ANSWER 13 OF 69  USPATFULL on STN
PI    US 7195736         B1  20070327
      WO 2001059170          20010816

L24  ANSWER 14 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE      APPLICATION NO.       DATE
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PI   JP 2006348321       A      20061228  JP 2005-173112        20050614

L24  ANSWER 15 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE      APPLICATION NO.       DATE
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PI   JP 2006299296       A      20061102  JP 2005-118366        20050415

L24  ANSWER 16 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE      APPLICATION NO.       DATE
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PI   JP 2006249457       A      20060921  JP 2005-64316         20050308

L24  ANSWER 17 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE      APPLICATION NO.       DATE
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PI   JP 2006206967       A      20060810  JP 2005-21019         20050128

L24  ANSWER 18 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE      APPLICATION NO.       DATE
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PI   JP 2006037177       A      20060209  JP 2004-220223        20040728

L24  ANSWER 19 OF 69  USPATFULL on STN
PI    US 20060285992     A1  20061221

L24  ANSWER 20 OF 69  USPATFULL on STN
PI    US 20060239853     A1  20061026

L24  ANSWER 21 OF 69  USPATFULL on STN
PI    US 20060157163     A1  20060720

L24  ANSWER 22 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
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PI   JP 2005220423       A      20050818  JP 2004-30993         20040206

L24  ANSWER 23 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE      APPLICATION NO.       DATE
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PI   JP 2005059096       A      20050310  JP 2004-199624        20040706

L24  ANSWER 24 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.          KIND   DATE      APPLICATION NO.       DATE
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PI   FR 2868083          A1     20050930  FR 2004-3038          20040324
     FR 2868083          B1     20060721
     AU 2005232002       A1     20051020  AU 2005-232002        20050321
     CA 2559562          A1     20051020  CA 2005-2559562       20050321
     WO 2005098070       A2     20051020  WO 2005-FR684         20050321
     WO 2005098070       A3     20061005
          W:  AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH,
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              GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
              LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI,
              NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM,
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         RW: BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM,
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              EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT,
              RO, SE, SI, SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML,
              MR, NE, SN, TD, TG
    EP 1727919            A2    20061206    EP 2005-742733          20050321
        R: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE,
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              HR, LV, MK, YU
    CN 1950533            A     20070418    CN 2005-80014026        20050321
    BR 2005008776         A     20070904    BR 2005-8776            20050321
    JP 2007530780         T     20071101    JP 2007-504447          20050321
    US 20070193658        A1    20070823    US 2006-593463          20060919
    MX 2006010816         A     20061120    MX 2006-10816           20060921
    IN 2006CN03491        A     20070615    IN 2006-CN3491          20060922
    KR 2007021185         A     20070222    KR 2006-722040          20061024


L24   ANSWER 25 OF 69   USPATFULL on STN
PI    US 20050265886      A1  20051201


L24   ANSWER 26 OF 69   USPATFULL on STN
PI    US 20050252580      A1  20051117


L24   ANSWER 27 OF 69   USPATFULL on STN
PI    US 20050207687      A1  20050922


L24   ANSWER 28 OF 69   USPATFULL on STN
PI    US 20050161125      A1  20050728


L24   ANSWER 29 OF 69   USPATFULL on STN
PI    US 20050058567      A1  20050317
      US 7445680          B2  20081104


L24   ANSWER 30 OF 69   USPATFULL on STN
PI    US 20050025658      A1  20050203


L24   ANSWER 31 OF 69   USPATFULL on STN
PI    US 20050022906      A1  20050203


L24   ANSWER 32 OF 69   CAPLUS   COPYRIGHT 2009 ACS on STN
      PATENT NO.          KIND   DATE        APPLICATION NO.        DATE
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PI    JP 2004292929       A      20041021    JP 2003-89959         20030328
      JP 3912308          B2     20070509


L24   ANSWER 33 OF 69   CAPLUS   COPYRIGHT 2009 ACS on STN
      PATENT NO.          KIND   DATE        APPLICATION NO.        DATE
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PI    JP 2004025205       A      20040129    JP 2002-182228        20020621
      JP 3789856          B2     20060628


L24   ANSWER 34 OF 69   USPATFULL on STN
PI    US 20040129243      A1  20040708
      US 7472674          B2  20090106


L24   ANSWER 35 OF 69   USPATFULL on STN
PI    US 20040055667      A1  20040325
      US 6911268          B2  20050628
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L24  ANSWER 36 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   JP 2003147482      A     20030521  JP 2001-349100        20011114
     JP 3851147         B2    20061129


L24  ANSWER 37 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   JP 2003147481      A     20030521  JP 2001-349097        20011114
     JP 3851146         B2    20061129


L24  ANSWER 38 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   JP 2003147479      A     20030521  JP 2001-349095        20011114
     JP 3901994         B2    20070404


L24  ANSWER 39 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   JP 2003147436      A     20030521  JP 2001-349099        20011114
     JP 3750737         B2    20060301


L24  ANSWER 40 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   JP 2003147435      A     20030521  JP 2001-349098        20011114
     JP 3747365         B2    20060222


L24  ANSWER 41 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   JP 2003073735      A     20030312  JP 2001-258353        20010828
     JP 4213370         B2    20090121


L24  ANSWER 42 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   FR 2830261         A1    20030404  FR 2002-11966         20020927
     JP 2003183770      A     20030703  JP 2002-112457        20020415
     JP 3468239         B2    20031117
     CN 1410581         A     20030416  CN 2002-144079        20020930
     CN 1180113         C     20041215
     US 20030084965     A1    20030508  US 2002-259744        20020930
     US 6838048         B2    20050104


L24  ANSWER 43 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND  DATE      APPLICATION NO.        DATE
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PI   EP 1335035         A1    20030813  EP 2003-250686        20030203
     EP 1335035         B1    20050420
         R:  AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT,
             IE, SI, LT, LV, FI, RO, MK, CY, AL, TR, BG, CZ, EE, HU, SK
     JP 2003226933      A     20030815  JP 2002-26368         20020204
     JP 3758581         B2    20060322
     TW 228149          B     20050221  TW 2003-92102006      20030129
     CN 1436875         A     20030820  CN 2003-103453        20030130
     CN 1210432         C     20050713
     US 20030152476     A1    20030814  US 2003-357419        20030204
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L24  ANSWER 44 OF 69  USPATFULL on STN
PI     US 20030178105      A1   20030925
       US 6764645          B2   20040720

L24  ANSWER 45 OF 69  USPATFULL on STN
PI     US 20030152476      A1   20030814

L24  ANSWER 46 OF 69  USPATFULL on STN
PI     US 20030138343      A1   20030724
       US 6797231          B2   20040928

L24  ANSWER 47 OF 69  USPATFULL on STN
PI     US 20030113223      A1   20030619
       US 6783728          B2   20040831

L24  ANSWER 48 OF 69  USPATFULL on STN
PI     US 20030084965      A1   20030508
       US 6838048          B2   20050104

L24  ANSWER 49 OF 69  USPATFULL on STN
PI     US 20030066577      A1   20030410
       US 6761853          B2   20040713

L24  ANSWER 50 OF 69  USPATFULL on STN
PI     US 6475305          B1   20021105

L24  ANSWER 51 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
       PATENT NO.          KIND  DATE      APPLICATION NO.        DATE
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PI     JP 2001234279       A     20010828  JP 2000-44821          20000222

L24  ANSWER 52 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
       PATENT NO.          KIND  DATE      APPLICATION NO.        DATE
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PI     JP 2001192765       A     20010717  JP 2000-193780         20000628
       JP 3253293          B2    20020204
       EP 1167561          A2    20020102  EP 2000-125344         20001130
          R:  AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT,
              IE, SI, LT, LV, FI, RO

L24  ANSWER 53 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
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PI     JP 2001152278       A     20010605  JP 1999-331045         19991122

L24  ANSWER 54 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
       PATENT NO.          KIND  DATE      APPLICATION NO.        DATE
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PI     JP 2001131684       A     20010515  JP 1999-314366         19991104

L24  ANSWER 55 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
       PATENT NO.          KIND  DATE      APPLICATION NO.        DATE
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PI     WO 2000044953       A1    20000803  WO 2000-JP369          20000125
          W:  CA, CN, KR, US
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       CA 2323952          A1    20000803  CA 2000-2323952        20000125
       EP 1069198          A1    20010117  EP 2000-900930         20000125
          R:  AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT,
              IE, FI
       CN 1113973          C     20030709  CN 2000-800083         20000125
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       JP 2000282172      A      20001010   JP 2000-18101         20000127
       JP 3680674         B2     20050810
       JP 2001214241      A      20010807   JP 2000-204882        20000706
       JP 3680708         B2     20050810
       US 6475305         B1     20021105   US 2000-669552        20000926

L24  ANSWER 56 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 2000273574      A      20001003   JP 1999-81629         19990325

L24  ANSWER 57 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 2000219936      A      20000808   JP 1999-23459         19990201

L24  ANSWER 58 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 2000026933      A      20000125   JP 1998-192878        19980708
     JP 3893756         B2     20070314

L24  ANSWER 59 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 11001743        A      19990106   JP 1998-52103         19980304
     JP 3489656         B2     20040126

L24  ANSWER 60 OF 69  USPATFULL on STN
PI      US 5972129                19991026

L24  ANSWER 61 OF 69  USPATFULL on STN
PI      US 5922145                19990713

L24  ANSWER 62 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 10152754        A      19980609   JP 1997-249242        19970912
     JP 3724142         B2     20051207

L24  ANSWER 63 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 09025541        A      19970128   JP 1995-175318        19950712

L24  ANSWER 64 OF 69  USPATFULL on STN
PI      US 5645794                19970708

L24  ANSWER 65 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 07150293        A      19950613   JP 1993-296667        19931126

L24  ANSWER 66 OF 69  CAPLUS  COPYRIGHT 2009 ACS on STN
     PATENT NO.         KIND   DATE       APPLICATION NO.        DATE
     ---------------    ----   --------   --------------------   --------
PI   JP 06248341        A      19940906   JP 1993-33687         19930223

L24  ANSWER 67 OF 69  USPATFULL on STN
PI      US 5107711                19920428

L24  ANSWER 68 OF 69  USPATFULL on STN
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PI     US 4991447          19910212

L24  ANSWER 69 OF 69  USPATFULL on STN
PI     US 4840073          19890620


=> d cost
COST IN U.S. DOLLARS                          SINCE FILE      TOTAL
                                                   ENTRY    SESSION
CONNECT CHARGES                                    15.24      32.59
NETWORK CHARGES                                     0.77       2.31
SEARCH CHARGES                                    105.28     582.80
DISPLAY CHARGES                                   123.01     228.13
                                                 -------    -------
FULL ESTIMATED COST                              244.30     845.83

DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)    SINCE FILE      TOTAL
                                                   ENTRY    SESSION
CA SUBSCRIBER PRICE                                0.00      -0.82

IN FILE 'CAPLUS, USPATFULL, SCISEARCH' AT 19:58:51 ON 31 JAN 2009


=> logoff
ALL L# QUERIES AND ANSWER SETS ARE DELETED AT LOGOFF
LOGOFF? (Y)/N/HOLD:y
COST IN U.S. DOLLARS                          SINCE FILE      TOTAL
                                                   ENTRY    SESSION
FULL ESTIMATED COST                              244.30     845.83

DISCOUNT AMOUNTS (FOR QUALIFYING ACCOUNTS)    SINCE FILE      TOTAL
                                                   ENTRY    SESSION
CA SUBSCRIBER PRICE                                0.00      -0.82

STN INTERNATIONAL LOGOFF AT 19:59:05 ON 31 JAN 2009
```